



NOVA SCOTIA

Environment

REPORT OF THE HALIFAX HARBOUR

MONITORING PROGRAM

REPORT OF THE HALIFAX HARBOUR
MONITORING PROGRAM

prepared by

NOVA SCOTIA DEPARTMENT OF THE ENVIRONMENT

in cooperation with

METROPOLITAN AREA PLANNING COMMISSION

Project Supervisor and Editor:
Ron S. Giffin P. Eng.
Environmental Engineer

Project Coordinator and Principal Author:
Pardis E. Khavari B.Sc. Hon.
MASC (candidate)

Research Associates and Coauthors:
Sheldon Downe B.Sc.S.
Vahid Kahnamelli B. Eng.

Research Associates:
Meenaskhi Bhasker B. Eng.
Bernard Matlock B. Eng.
Kerry MacQuarrie B. Eng

Research Assistant:
Maureen Wheller B.A.

May 1986

ACKNOWLEDGEMENTS

Halifax Harbour Pollution Monitoring Program was initiated and funded by Nova Scotia Department of the Environment in cooperation with Metropolitan Authority Area Planning Commission.

The members of the study team are grateful for:

- utilization of the sigma t boat of the Bedford Institute of Oceanography.
- the use of the search and rescue boat of the Canadian Coast Guard Base (Dartmouth).
- assistance of Mr. Darry MacPherson and Paul Longebardi of Pathology Lab for their assistance in laboratory set-up.
- assistance of Mr. Bill Horne in Laboratory operation.
- the helpful suggestions and time of Dr. Ramalaigiah.
- the sea level gauge reading provided by Mr. Steven Grant from Federal Department of Fisheries and Ocean.
- the marine vessel traffic data provided by Mr. M. Ouelett of Federal Department of transporation, Coast Guard.
- the seasonal data and sample collection from the site outside the Harbour provided by Mr. W.G. Lumsden and H.M.S. Quest of the Department of National Defence.
- providing the study with bacteriological analysis of the Harbour by Mr. D. Grantham of the Nova Scotia Department of Health.
- endless patience and knowledge provided by Mr. Ken Drinkwater in the biophysical oceanography aspect of this study.
- time and knowledge of Mr. Ali Khavari and Pardis E. Khavari in designing and implementing the computer graphics.
- the support of the objectives of this study by Mr. Brian Smith and Mr. Lou Dursi of MAPC.
- our deepest appreciation to Mr. Ron Giffin for his support of the staff and objectives of the study.

TABLE OF CONTENTS

	<u>PAGE</u>
Acknowledgements	i
Table of Contents	ii
List of Tables	v
List of Photoplates	vii
List of Maps	viii
List of Figures	ix
List of Seasonal Figures	xix
List of Reference Figures	xx
List of Appendix Tables	xxiii
 1.0 Executive Summary	 xxix
 2.0 Introduction	 1
2.1 Objectives of the Program	3
2.2 General Overview	4
 3.0 Description of the Study Areas	 13
3.1 Tufts Cove	19
3.2 Duffus Street	22
3.3 Dartmouth Cove	25
3.4 Sackville Street	29
3.5 Pier "A"	32
3.6 References	35
 4.0 Data Collection Procedures	 38
4.1 Marine and Wastewater Sampling Program	39
4.2 Water Quality Testing Conducted in the Field	41
4.2.1 Temperature	41
4.2.2 Dissolved Oxygen	41
4.2.3 Salinity	42
4.2.4 Conductivity	42
4.2.5 Transparency	42

4.3	Wastewater Quality Testing Conducted in the Laboratory	42
4.3.1	Chemical Oxygen Demand	42
4.3.2	Biochemical Oxygen Demand	43
4.3.3	Suspended Solids	44
4.3.4	pH	44
4.3.5	Total Coliform	44
4.3.6	Faecal Coliform	45
4.3.7	Total Plate Count	45
4.3.8	Staphylococcus	45
4.3.9	Pseudomonas	45
4.4	Water Quality Testing of Samples Collected Outside the Harbour	45
4.5	Record of Meteorological Conditions During the Sampling Period	46
4.6	Documentation of Sea Level and Tidal Activity	46
4.7	Halifax Harbour Marine Vessel Traffic	48
5.0	Analysis and Discussion	50
5.1	Analysis and Discussion of the Monthly Field and Laboratory Data	50
5.1.1	Temperature	51
5.1.2	Dissolved Oxygen	72
5.1.3	Salinity	94
5.1.4	Conductance	103
5.1.5	Transparency	116
5.1.6	Chemical Oxygen Demand	125
5.1.7	Biochemical Oxygen Demand and BOD Profiles	141
5.1.8	Suspended Solids	181
5.1.9	pH	201
5.1.10	Bacterial Data	210
5.2	Analysis and Discussion of the Seasonal Data	229
5.2.1	Temperature	229
5.2.2	Dissolved Oxygen	232
5.2.3	Salinity	235
5.2.4	Conductivity	239
5.2.5	Chemical Oxygen Demand	243
5.2.7	Biochemical Oxygen Demand	247
5.2.8	Suspended Solids	250
5.2.9	pH	253

5.3	Analysis and Discussion of Reference Data	256
5.3.1	Temperature	257
5.3.2	Dissolved Oxygen	259
5.3.3	Salinity	261
5.3.4	Conductivity	264
5.3.5	Transparency	266
5.3.6	Chemical Oxygen Demand	266
5.3.7	Biochemical Oxygen Demand	269
5.3.8	Suspended Solids	269
5.3.9	pH	271
5.4	Effects of Turbulent Processes on Halifax Harbour Contaminant Mixing, Dispersion and Removal	274
5.5	Visual Indications of the Pollution Within the Outfall Areas	284
5.6	Analysis of Core Sampling Data	295
5.7	Regression Analysis of the Daily Field and Laboratory Data	303
Appendices		
A	Halifax Harbour Monthly Field Data	318
B	Halifax Harbour Monthly Laboratory Data	371
C	Halifax Harbour Seasonal Field Data	393
D	Halifax Harbour Seasonal Laboratory Data	424
R	Halifax Harbour Seasonal Reference Data	432
Bibliography		456

LIST OF TABLES

<u>TABLE</u>	<u>TITLE</u>	<u>PAGE</u>
2-1	The freshwater influx into the Halifax Inlet	6
2-2	Population Projection for Halifax/Dartmouth	8
2-3	The area and population serviced by the Millcove and Eastern Passage treatment plants	9
2-4	Average flow estimates for Halifax/Dartmouth and municipalities .	10
2-5	The amount of water used in Halifax/Dartmouth	11
3-1	Physical description of the five sewer outfall sites	15
4-1	Monthly meteorological data for Halifax/Dartmouth	47
4-2	Monthly Halifax Harbour traffic	49
5-1	Percent Reduction of Chemical Oxygen Demand at Tufts Cove	129
5-2	Percent Reduction of Chemical Oxygen Demand at Duffus Street	133
5-3	Percent Reduction of Chemical Oxygen Demand at Dartmouth Cove	135
5-4	Percent Reduction of Chemical Oxygen Demand at Sackville Street	137
5-5A	Percent Reduction of Chemical Oxygen Demand at Pier "A" (Plume 1)	139
5-5B	Percent Reduction of Chemical Oxygen Demand at Pier "A" (Plume 2)	140
5-6	Percent Reduciton of Biochemical Oxygen Demand at Tufts Cove	146
5-7	Percent Reduction of Biochemical Oxygen Demand at Duffus Street	150
5-8	Percent Reduction of Biochemical Oxygen Demand at Dartmouth Cove	152
5-9	Percent Reduction of Biochemical Oxygen Demand at Sackville Street	153
5-10A	Percent Reduction of Biochemical Oxygen Demand at Pier "A" (Plume 1)	155

<u>TABLE</u>	<u>TITLE</u>	<u>PAGE</u>
5-10B	Percent Reduction of Biochemical Oxygen Demand at Pier "A" (Plume 2)	156
5-11	Percent Reduction of Suspended Solids at Tufts Cove	187
5-12	Percent Reduction of Suspended Solids at Duffus Street.	192
5-13	Percent Reduction of Suspended Solids at Dartmouth Cove	194
5-14	Percent Reduction of Suspended Solids at Sackville Street	195
5-15A	Percent Reduction of Suspended Solids at Pier "A" (Plume 1)	198
5-15B	Percent Reduction of Suspended Solids at Pier "A" (Plume 2)	199
5-16	Percent Reduction of Pollutants due to Dilution from the Manhole to the Plume	200
5-17	Bacteriological analysis of Tufts Cove outfall	222
5-18	Bacteriological analysis of Duffus Street outfall area	223
5-19	Bacteriological analysis of Dartmouth Cove outfall area	224
5-20	Bacteriological analysis of Sackville Street outfall area	225
5-21	Bacteriological analysis of Pier "A" outfall area	226
5-22	Bacteriological analysis of spring references	227
5-23	Bacteriological analysis of summer references	227
5-24	The statistics of inshore fishing in the vicinity of Eastern Passage and entrance to Halifax Harbour for 1984-1985	228
5-25	General information and observations on sampling days for Tufts Cove	286
5-26	General information and observations on sampling days for Duffus Street	287
5-27	General information and observations on sampling days for Dartmouth Cove	289
5-28	General information and observations on sampling days for Sackville Street	290
5-29	General information and observations on sampling days for Pier "A"	293
5-30	Results of core sampling for the stations close to the outfalls in Halifax Harbour	302

LIST OF PHOTOPLATES

<u>PHOTOPLATES</u>	<u>TITLE</u>	<u>PAGE</u>
1.	Pier "A" trunk outfall	309
2.	Pier "A", 914 mm pipe outfall at lowtide with evident biofouling of wharf	309
3.	Dartmouth Cove outfall from Maitland Street	310
4.	Dartmouth Cove outfall from Old Ferry Road	310
5.	Tufts Cove outfall at lowtide with sludge banks visible	311
6.	Duffus Street outfall at lowtide	311
7.	Sackville Street outfall at lowtide with evident biofouling on the pipe supports	312
8.	Tufts Cove and Duffus Street suspended solid filters with references included	313
9.	Tufts Cove suspended solid filters for spill of November 28, 1985	313
10.	Tufts Cove spill sample	314
11.	Tufts Cove spill sample	314
12.	Tufts Cove outfall showing the extent of dispersion of discoloured plume	315
13.	Tufts Cove outfall showing the extent of dispersion of discoloured plume	315
14.	Core sampler	316
15.	Sludge core of Duffus Street	316
16.	Sludge core of Tufts Cove	317
17.	Sludge core of Dartmouth Cove	317

LIST OF MAPS

<u>MAP</u>	<u>TITLE</u>	<u>PAGE</u>
3-0	Halifax-Dartmouth regional plan review sewerage, water supply and storm drainage study	
3-1	Location of sewer outfalls within the study area	14
3-2	Sampling stations for Tufts Cove outfall area	20
3-3	Bathymetry for Tufts Cove Outfall Area	21
3-4	Sampling stations for Duffus Street outfall area	23
3-5	Bathymetry for Duffus Street Outfall Area	24
3-6	Sampling stations for Dartmouth Cove Outfall Area	27
3-7	Bathymetry for Dartmouth Cove Outfall Area	28
3-8	Sampling Stations for Sackville Street Outfall Area	30
3-9	Bathymetry for Sackville Street Outfall Area	31
3-10	Sampling Stations for Pier A Outfall Area	33
3-11	Bathymetry for Pier A Outfall Area	34
3-12	Location of Reference Stations in the Study Area	36
3-13	Bottom configuration of the outfall area at Tufts Cove	298
3-14	Bottom configuration of the outfall area at Duffus Street	299

LIST OF FIGURES

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
5.01 A&B	Temperature variation at the surface and bottom for Tufts Cove, February, 1985	53
5.02 A&B	Temperature variation at the surface and bottom for Tufts Cove, March, 1985	54
5.03 A&B	Temperature variation at the surface and bottom for Tufts Cove, April, 1985	55
5.04 A&B	Temperature variation at the surface and bottom for Tufts Cove, May, 1985	56
5.05 A&B	Temperature variation at the surface and bottom for Tufts Cove, June, 1985	57
5.06 A&B	Temperature variation at the surface and bottom for Tufts Cove, July, 1985.	58
5.07 A&B	Temperature variation at the surface and bottom for Tufts Cove, August, 1985	59
5.08 A&B&C	Temperature variation at the surface, 5 m depth and bottom for Duffus Street, February, 1985	61
5.09 A&B&C	Temperature variation at the surface, 5 m depth and bottom, for Duffus Street, March, 1985	62
5.10 A&B&C	Temperature variation at the surface, 5 m depth and bottom, for Duffus Street, April, 1985	63
5.11 A&B&C	Temperature variation at the surface, 5 m depth and bottom, for Duffus Street, May, 1985	64
5.12 A&B&C	Temperature variation at the surface, 5 m depth and bottom, for Duffus Street, June, 1985	65
5.13 A&B&C	Temperature variation at the surface, 5 m depth and bottom, for Duffus Street, July, 1985	66
5.14 A&B&C	Temperature variation at the surface, 5 m depth and bottom, for Duffus Street, August, 1985	67
5.15 A&B	Dissolved oxygen distribution pattern at the surface and bottom, for Tufts Cove for February, 1985	74
5.16 A&B	Dissolved oxygen distribution pattern at the surface and bottom, for Tufts Cove for March, 1985	75

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
5.17 A&B	Dissolved oxygen distribution pattern at the surface and bottom, for Tufts Cove for April, 1985	76
5.18 A&B	Dissolved oxygen distribution pattern at the surface and bottom, for Tufts Cove for May, 1985	77
5.19 A&B	Dissolved oxygen distribution pattern at the surface and bottom, for Tufts Cove for June, 1985	78
5.20 A&B	Dissolved oxygen distribution pattern at the surface and bottom, for Tufts Cove for July, 1985	79
5.21 A&B	Dissolved oxygen distribution pattern at the surface and bottom, for Tufts Cove for August, 1985	80
5.22 A&B&C	Dissolved oxygen distribution pattern at the surface, 5m depth and bottom, Duffus Street for February, 1985 . . .	82
5.23 A&B&C	Dissolved oxygen distribution pattern at the surface, 5m depth and bottom, Duffus Street for March, 1985	83
5.24 A&B&C	Dissolved oxygen distribution pattern at the surface, 5m depth and bottom, Duffus Street for April, 1985	84
5.25 A&B&C	Dissolved oxygen distribution pattern at the surface, 5m depth and bottom, Duffus Street for May, 1985	85
5.26 A&B&C	Dissolved oxygen distribution pattern at the surface, 5m depth and bottom, Duffus Street for June, 1985	86
5.27 A&B&C	Dissolved oxygen distribution pattern at the surface, 5m depth and bottom, Duffus Street for July, 1985	87
5.28 A&B&C	Dissolved oxygen distribution pattern at the surface, 5m depth and bottom, Duffus Street for August, 1985	88
5.29	Monthly averages of salinity (o/oo) for the stations at the Tufts Cove Outfall, 1985	97
5.30	Monthly averages of salinity (o/oo) for all the stations at the surface, 5m depth and bottom, for Duffus Street . . . Outfall, 1985.	99
5.31	Monthly averages of conductivity ($100 \times \mu\Omega$ /cm) for the stations 50 m away from the plume at Tufts Cove, 1985 . . .	105
5.32	Monthly averages of conductivity ($100 \times \mu\Omega$ /cm) for the stations 100 m away from the plume at Tufts Cove, 1985 . .	106

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
5.33	Monthly averages of conductivity ($100 \times \mu\Omega$ /cm) for the stations 150 m away from the plume at Tufts Cove, 1985 . .	107
5.34	Monthly averages of conductivity ($100 \times \mu\Omega$ /cm) for the stations 50 m away from the plume at Duffus Street, 1985 . .	110
5.35	Monthly averages of conductivity ($100 \times \mu\Omega$ /cm) for the stations 100 m away from the plume at Duffus Street, 1985 .	111
5.36	Monthly averages of conductivity ($100 \times \mu\Omega$ /cm) for the stations 150 m away from the plume at Duffus Street, 1985 .	112.
5.37	Monthly averages of secchi disc (m) for the plume and stations 50m , 100m and 150m away from the plume for Tufts Cove, 1985	118
5.38	Monthly averages of secchi disc readings for Tufts Cove, 1985	119
5.39	Monthly averages of secchi disc (m) for the plume and stations 50m, 100 m and 150 m away from the plume for Duffus Street, 1985	121
5.40	Monthly averages of secchi disc readings for Duffus Street, 1985	122
5.41	Monthly averages of chemical oxygen demand for manhole, plume and references at Tufts Cove, 1985	127
5.42A&B	Monthly averages of chemical oxygen demand for the surface, and depth stations, 50 m from the plume at Tufts Cove . . .	127
5.43A&B	Monthly averages of chemical oxygen demand for the surface and depth stations, 100 m from the plume at Tufts Cove . .	128
5.44A&B	Monthly averages of chemical oxygen demand for the surface and depth stations, 150 m from the plume at Tufts Cove . .	128
5.45	Monthly averages of biochemical oxygen demand for manhole, plume and references at Tufts Cove, 1985	144
5.46	Monthly averages of chemical oxygen demand (mg/L) for manhole, plume and references at Duffus Street, 1985 . . .	131
5.47A&B	Monthly averages of chemical oxygen demand (mg/L) for the surface and depth stations, 50 m from the plume at Duffus Street	131

5.48A&B	Monthly averages of chemical oxygen demand (mg/L) for the surface and depth stations, 100 m from the plume at Duffus Street	132
5.49A&B	Monthly averages of chemical oxygen demand (mg/L) for the surface and depth stations 150 m from the plume at Duffus Street	132
5.50	Monthly averages of biochemical oxygen demand (mg/L) for the surface stations, 50 m from the plume at Tufts Cove	144
5.51	Monthly averages of biochemical oxygen demand (mg/L) for the depth stations, 50 m from the plume at Tufts Cove	144
5.52	Monthly averages of biochemical oxygen demand (mg/L) for the surface stations, 100 m from the plume at Tufts Cove . . .	145
5.53	Monthly averages of biochemical oxygen demand (mg/L) for the depth stations, 100 m from the plume at Tufts Cove . . .	145
5.54	Monthly averages of biochemical oxygen demand (mg/L) for the surface stations, 150 m from the plume at Tufts Cove . .	145
5.55	Monthly averages of biochemical oxygen demand (mg/L) for the depth stations, 150 m from the plume at Tufts Cove . . .	145
5.56	Monthly averages of biochemical oxygen demand (mg/L) for the manhole and plume at Duffus Street	148
5.57	Monthly averages of biochemical oxygen demand (mg/L) for the surface stations, 50 m from the plume at Duffus Street . .	148
5.58	Monthly averages of biochemical oxygen demand (mg/L) for the depth stations, 50 m from the plume at Duffus Street . . .	148
5.59	Monthly averages of biochemical oxygen demand (mg/L) for the surface stations, 100 m from the plume at Duffus Street .	149
5.60	Monthly averages of biochemical oxygen demand (mg/L) for the depth stations, 100 from the plume at Duffus Street . . .	149
5.61	Monthly averages of biochemical oxygen demand (mg/L) for the surface stations, 150 m from the plume at Duffus Street .	149
5.62	Monthly averages of biochemical oxygen demand (mg/L) for the depth stations, 150 from the plume at Duffus Street . . .	149
5.63	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove Outfall, September, 1984	158

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
5.64	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove Outfall, September, 1984	158
5.65	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove Outfall, October, 1984	159
5.66	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove Outfall, October, 1984	159
5.67	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove Outfall, November, 1984	160
5.68	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove Outfall, November, 1984	160
5.69	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove Outfall, December, 1984	161
5.70	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove Outfall, December, 1984	161
5.71	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove Outfall, February, 1985	162
5.72	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove Outfall, February, 1985	162
5.73	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove Outfall, March, 1985	163
5.74	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove Outfall, March, 1985	163

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
5.75	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove Outfall, April, 1985	164
5.76	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove Outfall, April, 1985	164
5.77	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove Outfall, May, 1985	165
5.78	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove Outfall, May, 1985	165
5.79	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove Outfall, June, 1985	166
5.80	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove Outfall, June, 1985	166
5.81	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove Outfall, July, 1985	167
5.82	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove outfall, July, 1985	167
5.83	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove Outfall, August, 1985	168
5.84	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Tufts Cove Outfall, August, 1985	168
5.85	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, September, 1984	170

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
5.86	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, September, 1984	170
5.87	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, October, 1984	171
5.88	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, October, 1984	171
5.89	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, November, 1984	172
5.90	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, November, 1984	172
5.91	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, December, 1984	173
5.92	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, December, 1984	173
5.93	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, February, 1985	174
5.94	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, February, 1985	174
5.95	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, March, 1985	175
5.96	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, March, 1985	175

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
5.97	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, April, 1985	176
5.98	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, April, 1985	176
5.99	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, May, 1985	177
5.100	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, May, 1985	177
5.101	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, June, 1985	178
5.102	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, June, 1985	178
5.103	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, July, 1985	179
5.104	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, July, 1985	179
5.105	Surface profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, August, 1985	180
5.106	Depth profiles of the monthly averages of biochemical oxygen demand (mg/L) at Duffus Street Outfall, August, 1985	180
5.107	Monthly averages of suspended solids (mg/L) for the manhole, plume and references at Tufts Cove, 1985	185
5.108	Monthly averages of suspended solids (mg/L) for the surface stations, 50 m from the plume at Tufts Cove	185

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
5.109	Monthly averages of suspended solids (mg/L) for the depth stations, 50 m from the plume at Tufts Cove	185
5.110	Monthly averages of suspended solids (mg/L) for the surface stations, 100 m from the plume at Tufts Cove	186
5.111	Monthly averages of suspended solids (mg/L) for the depth stations, 100 m from the plume at Tufts Cove	186
5.112	Monthly averages of suspended solids (mg/L) for the surface stations, 150 m from the plume at Tufts Cove	186
5.113	Monthly averages of suspended solids (mg/L) for the depth stations, 150 m from the plume at Tufts Cove	186
5.114	Monthly averages of suspended solids (mg/L) for the manhole and plume at Duffus Street	190
5.115	Monthly averages of suspended solids (mg/L) for the surface stations, 50 m from the plume at Duffus Street	190.
5.116	Monthly averages of suspended solids (mg/L) for the depth stations, 50 m from the plume at Duffus Street	190
5.117	Monthly averages of suspended solids (mg/L) for the surface stations, 100 m from the plume at Duffus Street	191
5.118	Monthly averages of suspended solids (mg/L) for the depth stations, 100 m from the plume at Duffus Street	191
5.119	Monthly averages of suspended solids (mg/L) for the surface station, 150 m from the plume at Duffus Street	191
5.120	Monthly averages of suspended solids (mg/L) for the depth stations, 150 m from the plume at Duffus Street	191
5.121	Monthly Averages of pH using $[H^+]$ for the surface stations, 50 m from the plume at Tufts Cove	203
5.122	Monthly Averages of pH using $[H^+]$ for the depth stations, 50 m from the plume at Tufts Cove	203
5.123	Monthly Averages of pH using $[H^+]$ for the surface stations, 100 m from the plume at Tufts Cove	203
5.124	Monthly Averages of pH using $[H^+]$ for the surface and depth stations, 100 m from the plume at Tufts Cove	203
5.125	Monthly Averages of pH using $[H^+]$ for the surface stations, 150 m from the plume at Tufts Cove	204

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
5.126	Monthly Averages of pH using $[H^+]$ for the depth stations, 150 m from the plume at Duffus Street	204
5.127	Monthly averages of pH using $[H^+]$ for the surface stations, 50 m from the plume at Duffus Street	206
5.128	Monthly averages of pH using $[H^+]$ for the depth stations 50 m from the plume at Duffus Street	206
5.129	Monthly averages of pH using $[H^+]$ for the surface stations 100 m from the plume at Duffus Street	206
5.130	Monthly averages of pH using $[H^+]$ for the depth stations 100 m from the plume at Duffus Street	206
5.131	Monthly averages of pH using $[H^+]$ for the surface stations 150 m from the plume at Duffus Street	207
5.132	Monthly averages of pH using $[H^+]$ for the depth stations 150 m from the plume at Duffus Street	207

LIST OF SEASONAL FIGURES

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
5.2.1	Seasonal averages of temperature ($^{\circ}\text{C}$) for the surface stations at Tufts Cove, 1984-1985	230
5.2.2	Seasonal averages of temperature ($^{\circ}\text{C}$) for the bottom stations at Tufts Cove, 1984-1985	230
5.2.3	Seasonal averages of temperature ($^{\circ}\text{C}$) for the surface stations at Duffus Street, 1984-1985	230
5.2.4	Seasonal averages of temperature ($^{\circ}\text{C}$) for the bottom stations at Duffus Street, 1984-1985	230
5.2.5	Seasonal averages of dissolved oxygen (mg/L) for the surface stations at Tufts Cove, 1984-1985	233
5.2.6	Seasonal averages of dissolved oxygen (mg/L) for the bottom stations at Tufts Cove, 1984-1985	233
5.2.7	Seasonal averages of dissolved oxygen (mg/L) for the surface stations at Duffus Street, 1984-1985	233
5.2.8	Seasonal averages of dissolved oxygen (mg/L) for the bottom stations at Duffus Street, 1984-1985	233
5.2.9	Seasonal averages of salinity (o/oo) for the surface stations at Tufts Cove, 1984-1985	237
5.2.10	Seasonal averages of salinity (o/oo) for the bottom stations at Tufts Cove, 1984-1985	237
5.2.11	Seasonal averages of salinity (o/oo) for the surface station at Duffus Street, 1984-1985	237
5.2.12	Seasonal averages of salinity (o/oo) for the bottom station at Duffus Street, 1984-1985	237
5.2.13	Seasonal averages of conductance ($100 \times \mu\Omega$ /cm) for the surface stations at Tufts Cove, 1985	241
5.2.14	Seasonal averages of conductance ($100 \times \mu\Omega$ /cm) for the bottom stations at Tufts Cove, 1985	241
5.2.15	Seasonal averages of conductance ($100 \times \mu\Omega$ /cm) for the surface stations at Duffus Street, 1985	241
5.2.16	Seasonal averages of conductance ($100 \times \mu\Omega$ /cm) for the bottom stations at Duffus Street, 1985	241

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
5.2.17	Seasonal averages of chemical oxygen demand (mg/L) for the surface and bottom stations at Tufts Cove, 1985 . . .	244
5.2.18	Seasonal averages of chemical oxygen demand (mg/L) for the surface and bottom stations at Duffus Street, 1985 . .	244
5.2.19	Seasonal averages of biochemical oxygen demand (mg/L) for the surface and bottom stations for Tufts Cove, 1985 .	248
5.2.20	Seasonal averages of biochemical oxygen demand (mg/L) for the surface and bottom stations at Duffus Street, 1985 .	248
5.2.21	Seasonal averages of suspended solids (mg/L) for the surface and bottom stations for Tufts Cove, 1984-1985	251
5.2.22	Seasonal averages of suspended solids (mg/L) for the surface and bottom stations at Duffus Street, 1984-1985	251
5.2.23	Seasonal averages of pH using [H+] for the surface and bottom stations at Tufts Cove, 1984-1985	254
5.2.24	Seasonal averages of pH using [H+] for the surface and bottom stations at Duffus Street, 1984-1985	254

LIST OF REFERENCE FIGURES

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
5.3.1	Fall seasonal averages of temperature ($^{\circ}\text{C}$) for reference stations, 1984	258
5.3.2	Winter seasonal averages of temperature ($^{\circ}\text{C}$) for reference stations, 1984-1985	258
5.3.3	Spring seasonal averages of temperature ($^{\circ}\text{C}$) for reference stations, 1985	258
5.3.4	Summer seasonal averages of temperature ($^{\circ}\text{C}$) for reference stations, 1985	258
5.3.5	Winter seasonal averages of salinity (o/oo) for reference stations, 1984-1985	262

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
5.3.6	Spring seasonal averages of salinity (o/oo) for reference stations, 1985	262
5.3.7	Summer seasonal averages of salinity (o/oo) for reference stations, 1985	263
5.3.8	Spring seasonal averages of conductance (100 x $\mu\Omega$ /cm) for reference stations, 1985	265
5.3.9	Summer seasonal averages of conductance (100 x $\mu\Omega$ /cm) for reference stations, 1985	265
5.3.10	Seasonal secchi disc (m) readings for reference stations, 1984-1985	267
5.3.11	Spring seasonal averages of chemical oxygen demand (mg/L) for reference stations, 1985	268
5.3.12	Summer seasonal averages of chemical oxygen demand (mg/L) for reference stations, 1985	268
5.3.13	Fall seasonal averages of biochemical oxygen demand (mg/L) for reference stations, 1984	270
5.3.14	Winter seasonal averages of biochemical oxygen demand (mg/L) for reference stations, 1984-1985	270
5.3.15	Spring seasonal averages of biochemical oxygen demand (mg/L) for reference stations, 1984	270
5.3.16	Summer seasonal averages of biochemical oxygen demand (mg/L) for reference stations, 1985	270
5.3.17	Fall seasonal averages of suspended solids (mg/L) for reference stations, 1985	272
5.3.18	Winter seasonal averages of suspended solids (mg/L) for reference stations, 1984-1985	272
5.3.19	Spring seasonal averages of suspended solids (mg/L) for reference stations, 1985	272
5.3.20	Summer seasonal averages of suspended solids (mg/L) for reference stations, 1985	272
5.3.21	Fall seasonal averages of pH using [H+] for reference stations, 1984.	273

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
5.3.22	Winter seasonal averages of pH using [H+] for reference stations, 1984-1985	273
5.3.23	Spring seasonal averages of pH using [H+] for reference stations, 1985	273
5.3.24	Summer seasonal averages of pH using [H+] for reference stations, 1985	273
5.3.25	Fall seasonal averages of dissolved oxygen (mg/L) for reference stations, 1984	260
5.3.26	Winter seasonal averages of dissolved oxygen (mg/) for reference stations, 1984-1985	260
5.3.27	Spring seasonal averages of dissolved oxygen (mg/L) for reference stations, 1985	260
5.3.28	Summer seasonal averages of dissolved oxygen (mg/L) for reference stations, 1985	260

LIST OF APPENDIX TABLES

<u>TABLE</u>	<u>TITLE</u>	<u>PAGE</u>
A.1.1	Monthly field averages of temperature ($^{\circ}\text{C}$), for Tufts Cove, February-August, 1985	318
A.1.2	Monthly field averages of temperature ($^{\circ}\text{C}$), for Duffus Street, February-August, 1985	320
A.1.3	Monthly field averages of temperature ($^{\circ}\text{C}$), For Dartmouth Cove, February-August, 1985	323
A.1.4	Monthly field averages of temperature ($^{\circ}\text{C}$), for Sackville Street, February-August, 1985	325
A.1.5	Monthly field averages of temperature ($^{\circ}\text{C}$), for Pier A, February-August, 1985	327
A.2.1	Monthly field averages of dissolved oxygen (mg/L), for Tufts Cove, February-August, 1985	329
A.2.2	Monthly field averages of dissolved oxygen (mg/L), for Duffus Street, February-August, 1985	331
A.2.3	Monthly field averages of dissolved oxygen (mg/L), for Dartmouth Cove, February-August, 1985	334
A.2.4	Monthly field averages of dissolved oxygen (mg/L), for Sackville Street, February-August, 1985	336
A.2.5	Monthly field averages of dissolved oxygen (mg/L), for Pier A, February-August, 1985	338
A.3.1	Monthly field averages of salinity (o/oo), for Tufts Cove, February-August, 1985	340
A.3.2	Monthly field averages of salinity (o/oo), for Duffus Street, February-August, 1985	342
A.3.3	Monthly field averages of salinity (o/oo), for Dartmouth Cove, February-August, 1985	345
A.3.4	Monthly field averages of salinity (o/oo), for Sackville Street, February-August, 1985	347
A.3.5	Monthly field averages of salinity (o/oo), for Pier A, February-August, 1985	349
A.4.1	Monthly field averages of conductivity ($100 \times \mu\Omega/\text{cm}$), for Tufts Cove, February-August, 1985	351

<u>TABLE</u>	<u>TITLE</u>	<u>PAGE</u>
A.4.2	Monthly field averages of conductivity ($100 \times \mu\Omega / \text{cm}$), for Duffus Street, February-August, 1985	353
A.4.3	Monthly field averages of conductivity ($100 \times \mu\Omega / \text{cm}$), for Dartmouth Cove, February-August, 1985	356
A.4.4	Monthly field averages of conductivity ($100 \times \mu\Omega / \text{cm}$), for Sackville Street, February-August, 1985	358
A.4.5	Monthly field averages of conductivity ($100 \times \mu\Omega / \text{cm}$), for Pier A, February-August, 1985	360
A.5.1	Monthly field averages of secchi disc (m), for Tufts Cove, February-August, 1985	362
A.5.2	Monthly field averages of secchi disc (m), for Duffus Street, February-August, 1985	363
A.5.3	Monthly field averages of secchi disc (m), for Dartmouth Cove, February-August, 1985	363
A.5.4	Monthly field averages of secchi disc (m), for Sackville Street, February-August, 1985	364
A.5.5	Monthly field averages of secchi disc (m), for Pier A, February-August, 1985	364
A.6.1	Monthly field data for Oland's outfall (Young Street), June, 1985	365
A.6.2	Monthly field data for Oland's outfall (Young Street), July, 1985	366
A.6.3	Monthly field data for Oland's outfall (Young Street), August, 1985	367
A.7.1	Monthly field data for Historic Properties outfall, June, 1985	368
A.7.2	Monthly field data for Historic Properties outfall, July, 1985	369
A.7.3	Monthly field data for Historic Properties outfall, August, 1985	370
B.1.1	Monthly averages of chemical oxygen demand (mg/L) for Tufts Cove Sewer Outfall, April-August, 1985	371
B.1.2	Monthly averages of chemical oxygen demand (mg/L) for Duffus Street Sewer outfall, April-August, 1985	372

<u>TABLE</u>	<u>TITLE</u>	<u>PAGE</u>
B.1.3	Monthly averages of chemical oxygen demand (mg/L) for Dartmouth Cove Sewer Outfall, April-August, 1985	373
B.1.4	Monthly averages of chemical oxygen demand (mg/L) for Sackville Street Sewer Outfall, April-August, 1985	374
B.1.5	Monthly averages of chemical oxygen demand (mg/L) for Pier A Sewer Outfalls, April-August, 1985	375
B.2.1	Monthly averages of biochemical oxygen demand (mg/L) for Tufts Cove Sewer Outfall, September, 1984-August, 1985 . . .	376
B.2.2	Monthly averages of biochemical oxygen demand (mg/L) for Duffus Street Sewer Outfall, September, 1984-August, 1985 . .	377
B.2.3	Monthly averages of biochemical oxygen demand (mg/L) for Dartmouth Cove Sewer Outfalls, September, 1984-August, 1985 .	378
B.2.4	Monthly averages of biochemical oxygen demand (mg/L) for Sackville Street Sewer Outfall, February-August, 1985	379
B.2.5	Monthly averages of biochemical oxygen demand (mg/L) for Pier A Sewer Outfalls, February-August, 1985.	380
B.3.1	Monthly averages of suspended solids (mg/L) for Tufts Cove Sewer Outfall, September, 1984-August, 1985 . . .	381
B.3.2	Monthly averages of suspended solids (mg/L) for Duffus Street Sewer Outfall, September, 1984-August, 1985 . .	382
B.3.3	Monthly averages of suspended solids (mg/L) for Dartmouth Cove Sewer Outfalls, September, 1984-August, 1985 .	383
B.3.4	Monthly averages of suspended solids (mg/L) for Sackville Street Sewer Outfall, February-August, 1985	384
B.3.5	Monthly averages of suspended solids (mg/L) for Pier A Sewer Outfalls, February-August, 1985	385
B.4.1	Monthly averages of pH using $[H^+]$ for Tufts Cove Outfall, September, 1984-August, 1985	386
B.4.2	Monthly averages of pH using $[H^+]$ for Duffus Street Outfall, September, 1984-August, 1985	387
B.4.3	Monthly averages of pH using $[H^+]$ for Dartmouth Cove Outfalls, September, 1984-August, 1985	388

<u>TABLE</u>	<u>TITLE</u>	<u>PAGE</u>
B.4.4	Monthly averages of pH using $[H^+]$ for Sackville Street Outfall, February-August, 1985	389
B.4.5	Monthly averages of pH using $[H^+]$ for Pier A Outfalls, February-August, 1985	390
B.5	Laboratory data, Oland's (Young Street) Outfall, June 7, July 24 and August 23, 1985	391
B.6	Laboratory data, Historic Properties Outfall, June 7, July 24 and August 23, 1985	392
C.1.1	Seasonal field averages of fall for Tufts Cove, September-November, 1984	393
C.1.2	Seasonal field averages of winter for Tufts Cove, December, 1984-February, 1985	394
C.1.3	Seasonal field averages of spring for Tufts Cove, March-May, 1985	395
C.1.4	Seasonal field averages of summer for Tufts Cove, June-August, 1985	397
C.2.1	Seasonal field averages of fall for Duffus Street, September-November, 1984	399
C.2.2	Seasonal field averages of winter for Duffus Street, December, 1984-February, 1985	401
C.2.3	Seasonal field averages of spring for Duffus Street, March-May, 1985	403
C.2.4	Seasonal field averages of summer for Duffus Street, June-August, 1985	405
C.3.1	Seasonal field averages of fall for Dartmouth Cove, September-November, 1985	407
C.3.2	Seasonal field averages of winter for Dartmouth Cove, December, 1984-February, 1985	408
C.3.3	Seasonal field averages of spring for Dartmouth Cove, March-May, 1985	410
C.3.4	Seasonal field averages of summer for Dartmouth Cove, June-August, 1985	412
C.4.2	Seasonal field averages of winter for Sackville Street, February, 1985	414

<u>TABLE</u>	<u>TITLE</u>	<u>PAGE</u>
C.4.3	Seasonal field averages of spring for Sackville Street, March-May, 1985	416
C.4.4	Seasonal field averages of summer for Sackville Street, June-August, 1985	418
C.5.2	Seasonal field averages of winter for Pier A, December, 1984-February, 1985	420
C.5.3	Seasonal field averages of spring for Pier A, March-May, 1985	422
C.5.4	Seasonal field averages of summer for Pier A, June-August, 1985	423
D.1.1	Seasonal averages of Chemical Oxygen Demand (mg/L) for Tufts Cove sewer outfall, 1985	424
D.1.2	Seasonal averages of Biochemical Oxygen Demand (mg/L) for Tufts Cove sewer outfall, 1984-1985	424
D.1.3	Seasonal averages of Suspended Solids (mg/L) for Tufts Cove sewer outfall, 1984-1985	425
D.1.4	Seasonal averages of pH using [H+] for Tufts Cove sewer outfall, 1984-1985	425
D.2.1	Seasonal averages of Chemical Oxygen Demand (mg/L) for Duffus Street sewer outfall, 1985	426
D.2.2	Seasonal averages of Biochemical Oxygen Demand (mg/L) for Duffus Street sewer outfall, 1984-1985	426
D.2.3	Seasonal averages of Suspended Solids (mg/L) for Duffus Street sewer outfall, 1984-1985	427
D.2.4	Seasonal averages of pH using [H+] for Duffus Street sewer outfall, 1984-1985	427
D.3.1	Seasonal averages of Chemical Oxygen Demand (mg/L) for Dartmouth Cove sewer outfalls, 1985	428
D.3.2	Seasonal averages of Biochemical Oxygen Demand (mg/L) for Dartmouth Cove sewer outfalls, 1984-1985	428
D.3.3	Seasonal averages of Suspended Solids (mg/L) for Dartmouth Cove sewer outfalls, 1984-1985	429
D.3.4	Seasonal averages of pH using [H+] for Dartmouth Cove sewer outfalls, 1984-1985	429

<u>TABLE</u>	<u>TITLE</u>	<u>PAGE</u>
D.4.1	Seasonal averages of Chemical Oxygen Demand (mg/L) for Sackville Street sewer outfalls, 1985.	430
D.4.2	Seasonal averages of Biochemical Oxygen Demand (mg/L) for Sackville Street sewer outfall, 1984-1985.	430
D.4.3	Seasonal averages of Suspended Solids (mg/L) for Sackville Street sewer outfall, 1984-1985.	430
D.4.4	Seasonal averages of pH using [H+] for Sackville Street sewer outfall, 1984-1985	430
D.5.1	Seasonal averages of Chemical Oxygen Demand (mg/L) for Pier "A" sewer outfalls, 1985	431
D.5.2	Seasonal averages of Biochemical Oxygen Demand (mg/L) for Pier "A" sewer outfalls, 1984-1985	431
D.5.3	Seasonal averages of Suspended Solids (mg/L) for Pier "A", 1984-1985	431
D.5.4	Seasonal averages of pH using [H+] for Pier "A", 1984-1985	431
R.1	Field reference data for autumn, 1984.	432
R.2	Field reference data for winter, 1984-1985	436
R.3	Field reference data for spring, 1985	440
R.4	Field reference data for summer, 1985	445
R.5	Reference laboratory data for fall, 1984	450
R.6	Reference laboratory data for winter, 1984-1985	451
R.7	Reference laboratory data for spring, 1985	452
R.8	Reference laboratory data for summer, 1985	453
R.9	Field data for the reference site outside the Harbour	454
R.10	Laboratory data for reference site outside the Harbour	455

Section 1.0 Executive Summary

Halifax Inlet is a dynamic ecosystem which consists of Halifax Harbour, Bedford Basin, Sackville River and the Northwest Arm.

The dynamics of the Halifax Inlet waters are partially due to the presence of Bedford Basin, the narrowness of Halifax Harbour and the influx of freshwater from the Sackville River plus wastewater and storm runoff from surrounding areas. The major momentum of this system results from water circulation influenced by tides, mean and wind-induced currents. The resultant water circulation is the primary mechanism in the removal of contaminants entering the Inlet system by the continuous discharge of $1.65 \times 10^9 \text{ m}^3/\text{yr}$ of raw sewage.

The objectives of this study were to identify the present water quality of the Harbour and to establish the rate of wastewater dilution, dissipation, precipitation and assimilation limits of the ecosystem. The base-line data created by this study is essential for emphasizing the capabilities of Halifax Harbour to assimilate or remove pollutants as well as in deciding the necessity for alteration of present disposal practices.

During the study period of September 1984 to August 1985, inclusive, Tufts Cove, Duffus Street, Dartmouth Cove, Sackville Street and Pier "A" major outfall sites were monitored regularly. A total of more than 4,000 samples were collected from the manholes, outfall plumes and seawater. These were analyzed in the field and laboratory for fourteen wastewater quality parameters. Samples from eighteen reference sites were also analyzed to establish the extent of the dispersion fields of the plume waters, and to estimate the amount of contaminant transportation. These sites were located in the middle of the Harbour, across the Narrows and across the entrance of the Harbour. Daily documentation of aesthetic conditions of the outfall sites, sea level changes, tides and climatic conditions and marine vessel traffic was also conducted.

The pH of the plume waters was alkaline and within ± 1.8 pH units of normal seawater. There were horizontal and vertical pH fluctuations within

the plume waters indicating monthly and seasonal variations. Tufts Cove and Pier "A" had a wide pH range of 6.0 to 10.9 indicating discharges of industrial effluents and a high concentration of sewage.

The water circulation induced by tides, currents and prevailing storm conditions had an impact on the suspended solid input/removal ratio. There was a nominal reduction in suspended solids from the outfalls to the middle of the Harbour, which indicated the transportation of suspended solids to the Basin or to the coastal waters.

Stratification of the Harbour waters, as indicated by salinity and temperature data, was evident in May and the summer months. During October until early March the water columns throughout the Harbour were uniformly mixed. The depth and strength of the density gradients were unique for each outfall site and independent of the reference stations. The hydrodynamic superceding of fresh sewage on the Harbour waters was always evident, and in the winter of 1985 Sackville River waters were observed to override the Harbour waters beyond Dartmouth Cove. The conductivity data indicated the persistence of this condition. Conductivity of the outfall sites and Harbour waters indicated the presence of a high dissolved solid content, resulting from sewage as well as the supernatants of the sludge in the warmer months.

Secchi Disc readings indicated low transparency at all outfall sites. Pier "A" and Tufts Cove had particularly low Secchi Disc readings and deeply coloured plume waters. The transparencies of the sites in the middle of the Harbour were also lower than the normal seawater secchi disc readings.

Biodegradable contaminants were being diluted, physically removed or oxidized at a rate of 70-90% within the first 150 meters from the point of discharge. The "clumping" of the organics and bacteria, resulted in precipitation further contributing to Biochemical Oxygen Demand removal. There are expressed reservations as to the applicability of the Biochemical Oxygen Demand as a "standard test" for assessment of the organic contents of sewage in seawater, however the modified technique in association with other parameters can be utilized.

Assessment of the level of available oxygen in the plume waters of the outfall sites showed a depletion of dissolved oxygen to critical limits of 2.4 to 4.4 mg/L in the summer months. However, the Harbour waters appeared to have dissolved oxygen levels above 6.0 mg/L.

Interpretation of Bacteriological data also showed a net transport of the wastewater-related bacteria to the middle of the Harbour and out into the Basin and towards the coastal waters.

Analysis of the Chemical Oxygen Demand data indicated the accumulation of the chemicals in the plume waters. Industrial and institutional chemical contaminants were ultimately transported to the middle of the Harbour, into the Basin and ultimately out of the Harbour.

Aesthetic conditions of the outfall sites were generally unpleasant with Tufts Cove being the most unsightly followed by Pier "A", Sackville Street, Dartmouth Cove and Duffus Street. Surface debris is trapped against the shorelines by winds and currents, and the odour of sewage and gas bubbles associated with the sludge banks were present.

A brief survey of the sludge banks at the outfall sites indicated a continual accumulation of sewage content. Anaerobic conditions associated with the sludge further deteriorated the aesthetics.



Section 2.0 Introduction

The "Halifax Harbour Pollution Monitoring Program" was initiated to investigate the environmental impacts resulting from the disposal of raw sewage into this unique estuarine system. Disposal of raw industrial and sanitary sewage has been the norm, for Halifax, Dartmouth and municipalities, since the existence of the Port of Halifax; except for the County of Halifax that has recently introduced sewage treatment at Mill Cove and Eastern Passage. Recent trends of prosperity and economic expansion have resulted in an increase in the urbanized population of the twin cities. The commercial, industrial and institutional activities that have been implemented to support the population influx have resulted in production of an even greater volume of, and more diversified wastes. However, with the exception of the installation of the Bedford Highway Trunk Interceptor and treatment provided by some of the municipalities, the practice of raw sewage disposal has not been altered.

There are numerous impacts which can result from the discharge of raw industrial and commercial wastewater via the shoreline into the coastal estuaries. The implications of detrimental biological, chemical and physical alteration of the estuarine ecosystem resulting from these disposal practices are of major concern. Furthermore, the health, economic and social impacts on the surrounding communities has been documented to be of importance (London symposium, Gameson, 1974 and MIT, Myers and Harding, 1983). The magnitude of the impact is a function of the volume, source strength and nature of the waste, as well as the ultimate assimilative capacity of the receiving waters. This is dictated by the depth, volume and flushing rate of the estuaries. The waters and sediments of Halifax Harbour are habitats for a great variety of organisms which exist in a delicate ecological balance. Any alterations in the water quality that effects this equilibrium, directly or indirectly, could have an impact on the surrounding biota.

A review of literature about Halifax Harbour reveals that since "Halifax Harbour Pollution" became of interest, the concept of secondary sewage treatment was emphasized as the solution. Very few studies have even

attempted logically, to quantify and qualify what actually happened due to the introduction of pollutants to this ecosystem. In other words, there are numerous questions which remain unanswered, such as:

(1) What is the quality and quantity of the wastewater discharged by the cities and municipalities into the Harbour? (2) How does the sewage effect the immediate vicinity of the sewer outfalls (plume area)? (3) What is the extent of dispersion? (4) How large is the field of pollution? (5) What quantity of waste is being dissipated, precipitated, decomposed and simulated into the natural environment and within what distance from the point of discharge? (6) What quantity of waste is being removed by the mechanisms of natural integration? (7) What is the percent contaminant loading of the Halifax, Dartmouth and municipalities? (8) What and how effective are the mechanisms by which the pollution disperses, precipitates, decomposes or assimilates? (9) What is the quality and quantity of the residual that is being carried into the Basin or out of the Harbour? (10) What amount of pollution is being contributed into the Narrows from the Basin? (11) Is the wastewater pollution localized around the outfall or is it present throughout the Harbour?

Therefore, to answer the above questions, the present study was undertaken.

In order to create a better and more comprehensive estimate of the quality and quantity of the wastewater, five sewer outfalls were chosen that carried the largest volume of wastewater from the largest tributary areas with a more diverse level of land use activities. The section of Halifax Harbour that was studied is located between the MacKay Bridge and MacNab's Island for these reasons.

- 1) Both the cities of Halifax and Dartmouth are located on either side of this region of the Harbour.
- 2) The majority of the sewer outfalls from Halifax, Dartmouth and municipalities are located within this area.
- 3) The sewer outfalls located in this region receive the wastewater from a large watershed area with a very diverse level of land use activities.
- 4) The contaminants that are being discharged to the Bedford Basin will eventually pass through this section since the Basin is being flushed regularly.

- 5) Dry weather flow of sewage into the Northwest Arm constitutes a small portion of the total volume of wastewater received by the Harbour system.

Five outfall sites, located at Duffus Street, Tufts Cove, Dartmouth Cove, Sackville Street and Pier A, were monitored regularly. Selected other sites were sampled occasionally, these sites being located at Historic Properties, Oland's (Young Street), Jamieson and Grove Streets, plus the treatment plants of Mill Cove and Eastern Passage. Eighteen reference sites inside the Harbour and one outside, were visited seasonally. During the period of September of 1984 to August of 1985, a sum of 12 outfalls, 29 sites, 72 stations, 4,144 samples were tested for the surface and bottom stations for certain water quality parameters.

For a duration of 8 to 11 months (3-4 seasons) the water samples were tested for Temperature, Dissolved Oxygen, Salinity, Conductivity and Transparency in the field plus Chemical Oxygen Demand, Biochemical Oxygen Demand, Suspended Solids, pH, Total Coliform, Faecal Coliform, Total Plate Count, Streptococcus and Pseudomonas in the laboratory.

2.1 OBJECTIVES OF THE PROGRAM

The "Halifax Harbour Pollution Monitoring Project" was initiated to determine the impacts of raw sewage discharged into the Harbour. It was to manifest the present water quality of this estuarine ecosystem. The primary objectives of this study were:

1. To study the environmental impact of sewage disposal into Halifax Harbour.
2. To establish the quantity and quality of wastewater discharged from the cities and municipalities.
3. To clarify the level and mechanisms of possible dilution, dispersion, treatment, transportation and precipitation of waste from the points of discharge.

4. For the first time, establish baseline data on the present water quality of the Harbour in correlation with the raw sewage disposal practices.
5. To establish the aesthetic state of the Harbour in connection with the raw wastewater disposal.
6. To address the possible impacts of waste disposal on public health (presence of human waste), tourism (aesthetic problems) recreational use of the Halifax Harbour and Bedford Basin and fishing from areas close to Eastern Passage and inside the Harbour system.

The project group feels that this study is rather unique in its approach and scope in assessing the general condition of the Harbour. Even then it was felt by considering more sites and testing for more indicative parameters (such as: Total Organic Carbon, nutrients and Clostridium Perfringens), the monitoring project would have presented a more comprehensive description of the water quality of the Halifax Harbour ecosystem. However, the fact remains that the limitation of funds, basic knowledge about the study area, laboratory space and other considerations dictated the framework of the monitoring program.

2.2 General Overview

Halifax Harbour and Bedford Basin are two unique bodies of water. These two water bodies are amongst the best natural inland harbours along the Atlantic coast. The Halifax Inlet water system consists of the following: Bedford Basin, Halifax Harbour and the Northwest Arm. Halifax Harbour is approximately 7 km long and has variable depths and widths. Average depth of the Harbour is 16.9 meters in the northern section and 21.3 meters in the southern section. A range of 400 m to 2400 m has been observed for the width of the Harbour from the MacKay Bridge to the "crossing line" by McNabs Island. The surface area of the Harbour is 931.0 hectares. The Basin has 1,660 hectares of surface area, approximately 4 km wide, 7.5 km long with a maximum depth of 70 m. The Sackville River discharges into the northeastern section of the Basin. The Northwest Arm has a surface area of 160 hectares with an average depth of 11.9 meters and a length of 4.8 km. Halifax Inlet is

subjected to semi-diurnal tide cycles with tides ranging from 0.6 to 2.0 m, and a mean tide of 1.4 m (minimum 0.3 m, maximum 2.4 m).

Total volume of the Halifax Inlet is approximately $6.99 \times 10^8 \text{ m}^3$. This value is the sum of the following values: Halifax Harbour has a volume of $1.86 \times 10^8 \text{ m}^3$, while Bedford Basin has a volume of $4.96 \times 10^8 \text{ m}^3$ and the Northwest Arm has a volume of $1.69 \times 10^7 \text{ m}^3$. In 1976, an approximate volume of $8.7 \times 10^5 \text{ m}^3$ per day of freshwater was discharged from Sackville River to the Halifax Harbour system. Therefore, the annual freshwater influx of the Sackville River has been approximated at $3.2 \times 10^8 \text{ m}^3$.

The annual freshwater influx from sources other than wastewater is reported by the Metropolitan Authority Planning Commission (MAPC) report of October 1976 in Table 2-1.

An approximate annual domestic sewage influx of $7.8 \times 10^7 \text{ m}^3/\text{day}$ has been forecasted for the year 1991 by the same report. From this total, Halifax contributes an approximate value of $7.4 \times 10^4 \text{ m}^3/\text{day}$ of raw sewage and Dartmouth contributes $3.7 \times 10^4 \text{ m}^3/\text{day}$.

Halifax Inlet, from Herring Cove to Eastern Passage, has 52.26 kilometers of coast line. Dartmouth side of the Harbour, from Eastern Passage to MacKay Bridge, has 11.20 km, while Halifax, from MacKay Bridge to the tip of the Peninsula, has 7.70 kilometers, the Bedford Basin has 21.75 km and the Northwest Arm from Herring Cove to the tip of the Halifax Peninsula at Point Pleasant Park, has 11.61 km of shoreline. All along these shorelines there are various facilities located that directly or indirectly affect the water quality as well as aesthetic state of the Harbour.

The Halifax Inlet has the capacity to accomodate large size commercial and war ships, hence, the Halifax shoreline has a large number of piers and wharves to provide docking facilities for these marine vessels. At present an average of 419 marine vessels move in and out of the Harbour each week bringing the total ship movements to 12,563 for February-August, 1985. The size of these vessels vary from small 4 meter pleasure boats to container

Table 2-1: The freshwater influx into the Halifax Inlet water excluding the sewage input. Calculated by George Mateson; runoff coefficient is provided by MacLaren and the precipitation data by Corveatte; comparable values were estimated by H.H.P.M.P. (Rainfall intensity estimated for 2 years of 1984-1985).

Location Within the Inlet	Area		Runoff Coefficient	Total Annual Freshwater Influx	
	Hectare	Acre		Mm ³	MIG
Halifax Harbour Watershed	4,796 4,779*	11,845 11,804	0.80	68.926 59.260*	15,162 13,035*
Bedford Basin Watershed	1,848 1,822*	4,565 4,500*	0.70	23.239 19.767*	5,112 4,348*
Northwest Arm Watershed	2,290 2,290*	5,658 5,657*	0.70	28.808 24.849*	6,337 5,466*
Halifax Harbour Water body	1,175 931*	2,903 2,300*	1.00	21.116 14.431*	4,645 3,174*
Bedford Basin Water body	1,703 1,660*	4,206 4,100*	1.00	30.595 25.730*	6,730 5,660*
Northwest Arm Water body	213 160*	526 395*	1.00	3.828 2.480*	842 546*

* As calculated by the H.H.P.M.P., 1985.

ships and tankers that are approximately 25,000 metric tons (Table 4-2). The greatest impact of traffic on the Harbour logically would be from the vessels weighing 3,000 tons and up, since the baffling action produced by their propellers reaches the upper 10 m of the Harbour waters. The frequency of ship movement per day is also an important factor to take into account when considering reoxygenation and mixing of wastewaters.

In addition to the docking facilities and wharves, there are other structural intrusions and installations, such as thermal power plants, petroleum refineries, warehouses, container yards, railroad tracks, and highways. Besides providing industrial facilities, Halifax Harbour has great aesthetic potential and a combination of natural beauty, restaurants and historic sites which make it a popular tourist attraction.

The City of Halifax occupies an area of 63 km², while the City of Dartmouth has an area of 58.3 km². In total, Halifax Harbour services a total drainage area of 146 km². Both municipalities dispose of their untreated sewage by a combined and partially separated sewerage system.

In 1981, the total population of Halifax, Dartmouth and municipalities was 236,624. The City of Halifax had a population of 113,337, while 63,164 people resided in the City of Dartmouth. The Town of Bedford and Halifax county have a population of 60,123. Population projection for the year of 1986 has been reported as 304,883 by census Canada. However, the Regional Development Plan Review report a population of 273,071 for the year 1991, that translates into 1.2% increase in residences from that of 1981. The population of Halifax, Dartmouth and municipalities is to reach 320,280 by the year 2001. Therefore, the population breakdown of the tributary areas (as shown in the supplemented Map 1 is presented in Table 2-2).

There are two municipal wastewater disposal treatment plants discharging to the Inlet that belong to Halifax county. These treatment plants are: the Eastern Passage plant that treats the wastewater from an approximate area of 457 hectares from Cole Harbour, Eastern Passage and Shearwater with an ultimate population of 25,000 that has already been reached. The Mill Cove plant that services an area of 1,639 hectares from Bedford, Sackville and Sunnyside area with an approximate population of 39,000 (Table 2-3).

Table 2-2 Population projection for Halifax/Dartmouth and municipalities.
In accordance with the formulation of the Regional Development
Plan Review (1986).

	Population Projection		
	1981	1991	2001
Halifax Peninsula to Armdale Rotary	62,834	59,407	65,070
Dartmouth from Wright Cove to Shearwater	63,164	72,226	83,430
Halifax North	30,011	35,222	41,820
Halifax South	22,129	29,153	33,250
Lakeside and Timberlea	4,198	7,534	10,610
Town of Bedford	6,803	10,490	14,150
Waverley, Beaverbank and Sackville	29,102	34,984	41,260
Shearwater and Eastern Passage	18,383	24,055	30,130
Total	236,624	273,071	320,280

Table 2-3: The area and population serviced by the Mill Cove and Eastern Passage treatment plants, with consideration for ultimate design and capacities. (Extracted from MacLaren and Lavalin report, Nov. 1981).

	Year	Tributary		ADWF m ³ D	Design Flows		PWWF m ³ D
		Area	Population		ADWF MGD	PWWF MGD	
Eastern Passage	1981	1,440	18,000	6,510	10,184	1.40	2.19
	Present		22,600	6,800	34,600	1.50	7.60
	1986	1,850	25,000	8,835	40,734	1.90	8.76
	1991	2,260	32,000	11,114	47,895	2.34	10.30
	1996	2,500	36,000	12,416	52,080	2.67	11.20
	2001	2,850	42,000	14,415	56,963	3.10	12.25
	Ultimate	3,885	60,000	20,274	75,330	4.36	16.20
Mill Cove	1981	3,210	29,000	9,533	78,585	2.57	16.9
	Present			9,765	24,180	2.10	5.2
	1986	4,050	39,000	15,671	91,140	3.37	19.6
	1991	4,650	47,000	18,507	100,440	3.98	21.6
	1996	5,500	58,000	22,413	112,995	4.82	24.3
	2001	6,840	77,000	29,063	132,990	6.25	28.6
	Ultimate	10,060	132,000	46,965	189,255	10.10	40.7

Other wastewater treatment plants include the BIOX plant at Imperial Oil Refinery for industrial waste; holding ponds for tailwater from coal washing process at the Nova Scotia Power Commission. In addition, the City of Halifax has storm retention tanks for storm overflow on the Northwest Arm and Fairview Cove. The City of Dartmouth also has sewage holding tanks on the east side of Russell Lake and the west side of Topsail Lake. No exact data exists on the quantity of sewage discharged by these three municipalities to Inlet waters. However, the estimates of the flow by various sources approximate a value of 50 gallons per capita per day of domestic sanitary sewage (C. J. MacLaren, May, 1973) to 125 gallons per capita average dry weather flow and 400 gallons per capita per day peak wet weather flow (before the overflow takes place). The general consensus is that an approximate volume of 475 gallons per capita per day are to be intercepted by the combined sewer trunk for treatment (design flow recommended by the Water Resources Commission). The regional pollution control study indicates estimated average flow per unit as illustrated in Table 2-4.

Table 2-4: Average flow estimates for Halifax, Dartmouth and municipalities.

Year	1968	1985	2000
Land Use			
Residential:	27 Igpcd 303 Lpcd	34 Igpcd 382 Lpcd	40 Igpcd 449 Lpcd
Commercial:			
Core	6,680 Igpad 75,037 Lphd	7,400 Igpad 83,124 Lphd	8,000 Igpad 89,864 Lphd
Light	1,800 Igpad 20,219 Lphd	2,200 Igpad 24,713 Lphd	2,500 Igpad 28,083 Lphd
Institutional:			
University	2,800 Igpad 31,452 Lphd	2,900 Igpad 32,576 Lphd	3,000 Igpad 33,699 Lphd
Hospitals	12,000 Igpad 134,796 Lphd	13,600 Igpad 152,769 Lphd	15,000 Igpad 168,495 Lphd
Industrial:			
Heavy	11,700 Igpad 131,426 Lphd	11,800 Igpad 132,550 Lphd	12,000 Igpad 134,796 Lphd
Light	685 Igpad 7,695 Lphd	850 Igpad 9,548 Lphd	1,000 Igpad 11,233 Lphd
Infiltration:			
Minimum	2,500 Igpad 28,082 Lphd	2,500 Igpad 28,082 Lphd	2,500 Igpad 28,082 Lphd
Maximum	20,000 Igpad 224,660 Lphd	20,000 Igpad 224,660 Lphd	20,000 Igpad 224,660 Lphd

Igpcd = Imperial gallon per capita per day
 Igpad = Imperial gallon per acre per day
 Lpcd = Liters per capita per day
 Lphd = Liters per Hectare per day

According to an estimate of the water supplied, Halifax, Dartmouth and those towns serviced by the public water supply system use an average of 486.4 liters per capita per day of water, with consideration for seasonal variations. A total of 33.4 million m³ of water is being supplied to the area and potentially contributing to the sewage output from these municipalities. This value excludes the people using wells as a source of

their water supply. During 1984, 74% of the water was used by institutions, industries and larger water consumers but only had 6% of the installed water meters in Halifax. Therefore, only 26% of 22.4 million m³ of water is being consumed by the owners of the smaller meters. As indicated in Table 2-5, this percentage variation does not exist in Dartmouth.

Table 2-5: The amount of water consumed in Halifax and Dartmouth as reported by the Public Service Commission, 1984.

Municipality	Large Water Meters		Small Water Meters		Total	
	Mm ³	MIG	Mm ³	MIG	Mm ³	MIG
Halifax	16.6	3,650	5.8	1,282	22.4	4,927
Dartmouth	5.3	1,174	5.7	1,253	11.0	2,428

By a conservative estimate, 80% of the water supplied is returned in the form of sanitary sewage plus an estimated maximum infiltration of 224.7 m³ per hectare per day (due to poor design, construction and maintenance reported by H.J. Porter and Associates, 1977 to MAPC). The above flows plus the runoff resulting from 154.78 cm/year (from the raingauge on Citadel Hill) of the precipitation on the watershed results in an estimated flow of 7.24×10^8 m³/year of polluted freshwater to the Harbour (MacLaren). The calculated values for the study period of 84/85 is a maximum of 1.65×10^9 and minimum of 6.00×10^8 m³/year of freshwater to the Harbour; these estimates include the discharge from Sackville River. The calculation excludes the cooling water discharged from various industries, the effluents of the establishments that use other sources of water supply, ballast water plus other discharges from tankers and other ships in the Harbour. It is important to note that the discharge quality and quantity of the industrial effluent has not been measured or reported, but recently N.S.D.O.E. contracted a project to Porter Dillon that is addressing these questions.

Consideration of the industries located on the shoreline and discharging their effluent directly into the Harbour itself or into the public sewerage system is of extreme importance. Some major industries such as refineries and power plants have some measure of pollution control in place. However, the

efficiency and the control level of these facilities with or without treatment in place should be considered for a better comprehension of the magnitude and quality of discharge. The next logical priority is a close monitoring of the institutions, industries and commercial outlets for the quality and quantity of their effluent.

In general, the Halifax/Dartmouth area has commercial, industrial, institutional and residential land use activities. Heavy industries are located in areas in and around these two municipalities, for example the dry dock facility in Halifax and two lumber mills on the Sackville River. Industries such as refineries, shipyards, the Department of National Defense dockyards and the Breweries are present on both sides of the Harbour within the tributary area. Commercial centers and office buildings are more concentrated in downtown Halifax, shopping centers of various sizes are in the Mumford Road area and Dartmouth Northeast. In the case of Dartmouth the industrial area is more scattered than in Halifax but also concentrated along the shore. Burnside Industrial Park contains a high concentration of warehouses, shopping outlets, laboratories as well as small industries. The larger institutional centers such as Hospitals, Universities and Health Centers are located in the south end of Halifax with heavy concentration in a block from Quinpool Road to the end of Robie Street.

Single dwelling, residential areas are scattered throughout the cities of Halifax and Dartmouth with a greater density of single housing units on the Peninsula. The multiple residential apartment building also show similar concentration patterns.

Section 3.0 Description of the Study Area

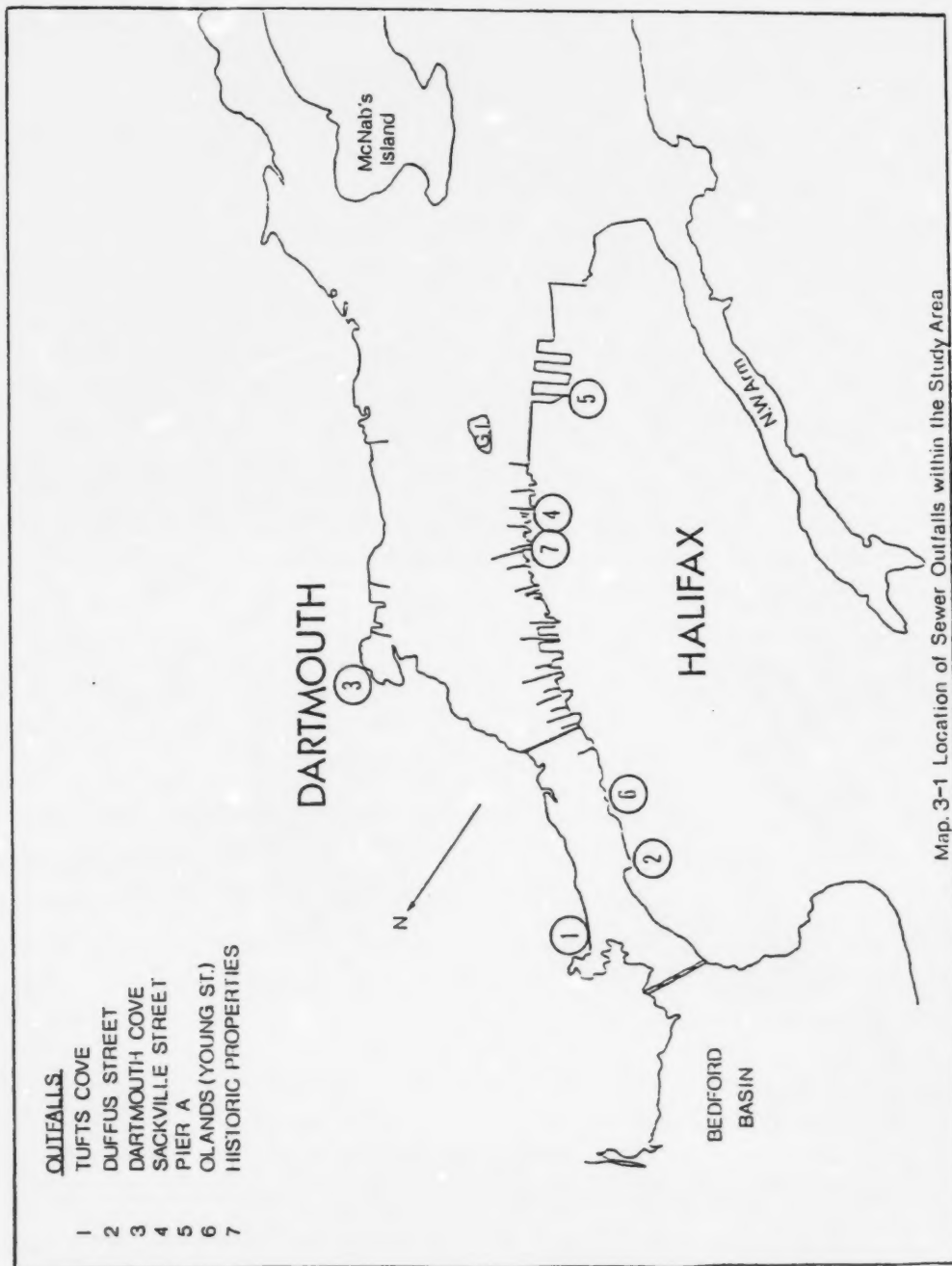
Initially, Halifax Harbour, from Point Pleasant Park to the MacKay Bridge, was to be considered for monitoring. Owing to the limitations of the project as well as the scope and the objectives chosen for the monitoring program, a decision was made to concentrate the effort on five major outfalls. These outfalls were Tufts Cove, Dartmouth Cove in Dartmouth and Duffus Street, Sackville Street and Pier A in Halifax (Map and Table 3-1).

The selection of these five outfalls were based on the following facts:

- a) A large volume of sewage is emanating from these sewer outfalls.
- b) The sanitary sewer trunks service a large population in the cities of Halifax and Dartmouth.
- c) They discharge effluent from relatively large tributary areas.
- d) The tributary areas chosen contain diverse and variable land use activities.

Respectively, the outfalls on the Halifax side of the Harbour receive effluent from an area of 17,196 Hectares. The catchment area of the outfalls in Halifax, comprise of three major divisions : (a) Halifax Peninsula (area from Point Pleasant Park to Fairview Cove) excluding a portion along the Northwest Arm; (b) Halifax North (area from Fairview Cove to the Halifax-Bedford city limits) and (c) portion of Halifax South (area located on the western side of the Northwest Arm). In the catchment area that was monitored, there is a population of 81,000 residing, with a high concentration of commercial, institutional and industrial activities.

The outfalls on the Dartmouth side of the Harbour, receive raw industrial and sanitary sewage from an area of 16,083 Ha. A population of 74,500 reside in the study area. The catchment areas that were monitored comprise of commercial, institutional and industrial activities, located on the eastern and northeastern side of the City of Dartmouth. The effluent emanating from Tufts Cove includes a considerable industrial component, while mostly sanitary sewage is being discharged from Dartmouth Cove outfalls.



Map. 3-1 Location of Sewer Outfalls within the Study Area

TABLE 3-1
THE PHYSICAL DESCRIPTION OF THE FIVE SEWER OUTFALL SITES OF THE STUDY AREA

Outfalls in:	Tufts Cove	Duffus Street	Dartmouth Cove	Sackville Street	Pier A
Location	44° 40' 43" N 63° 35' 59" W	44° 40' 17" N 63° 36' 00" W	44° 39' 50" N 63° 33' 47" W	44° 38' 46" N 63° 34' 10" W	44° 38' 04" N 63° 34' 04" W
Tributary Area	927.5 (22,292 Ac)	16,625 (41,080.4 Ac)	15,155 (37,448 Ac)	87.5 (216.2 Ac)	483 (1,193.5 Ac)
Percentage of the Tributary Area Developed	64.5%	Peninsula 100% Bedford Hwy 74.7%	63.8%	100%	100%
Sewer Outfall Pipe Size (mm)	1,067 (42") 1,219 (48")	3,048 (120")	1,524 (60") and 762 (30") 1,219 (48")	4 x 1,020 (40")	914 (36") 3,353 x 1,524 (11'4" x 5')
Outfall or Plume Area (ha)	12.5 (31 Ac)	10.0 (24.7 Ac)	17.5 (42.2 Ac)	3.0 (7.4 Ac)	10.0 (24.7 Ac)
Volume of the Plume considered (m ³)	2.25 x 10 ⁵	9.60 x 10 ⁵	8.75 x 10 ⁵	3.39 x 10 ⁵	9.31 x 10 ⁵
Mean Depth of the Outfall Pipe (m)	0.80 (2.6')	2.5 (8')	1.2 (400)	2.0 (6.5')	1.8 (5.7)
Maximum Depth of the Site (m)	10 (33')	20 (66')	9 (29.5')	18 (59')	18 (59')
Mean Depth (m)	1.8 (6')	9.6 (31.5')	5 (16.4')	11.3 (37')	9.3 (30.5)

A total population of 155,000 reside within 33,279 Hectares of the monitored catchment area. This is only 55% of the total population residing in Halifax, Dartmouth and vicinity. However, during a working day there is an influx of commuters.

By choosing these outfalls it has been attempted to create a better and more comprehensive understanding of the quality and quantity of the wastewater discharged. This monitoring program would enable the researchers and decision makers to assess the present condition of Halifax Harbour. It also assists in predicting future conditions that will result if the present raw sewage disposal practices were to continue.

In addition, the following combined sewer outfalls and storm overflows are listed for Halifax and Dartmouth.

Halifax:

- (1) Pier "A", 3,475 x 1,524 mm "old freshwater brook" tunnel and 914 mm combined sewer pipe which services the southend of Halifax.
- (2) Terminal Road, 762 mm combined sewer outfall services parts of Hollis South and Lower Water Street.
- (3) Salter Street overflow pipe services parts of Hollis, Lower Water, Barrington and Granville Street.
- (4) Sackville Street, 4 x 1,020 mm pipes which service a section of central Halifax.
- (5) Prince Street, 1,524 mm combined sewer outfall services a portion of Downtown from Argyle to Lower Water Street.
- (6) Historic Properties, 1,651 x 1,016 mm combined sewer services a largely commercial portion of Downtown Halifax from Brunswick to Lower Water Street.
- (7) A 1,219 mm storm runoff pipe services from Gottingen Street to Upper Water Street and from Cogswell Street to Duke Street.
- (8) Cornwallis Street, 1,219 mm combined sewer services an area from Brunswick Street to Upper Water Street.
- (9) A 914 mm pipe which services the Department of National Defence.
- (10) A 533 mm pipe which services Department of National Defence.

- (11) North Street, 762 mm combined sewage trunk which services Windsor Street to Barrington Street and Russell Street to North Street.
- (12) North Street, 610 mm overflow which discharges at D.N.D.
- (13) North Street, 610 mm overflow pipe to the North Street trunk.
- (14) Young Street, 762 mm combined sewer services a tributary area from Dublin Street to Barrington Street and from Sebastian Street to Russell Street. A portion of the wastewater is being discharged onto the shore.
- (15) Hanover Street, 610 x 762 mm combined sewer services a section of Barrington Street.
- (16) Kencrest Street, 762 mm carries the overflow from the area of Basinview Drive to Kencrest Street.
- (17) Gottingen Street, 914 mm storm and overflow pipe services a section of Halifax North and carries the wet weather flow from the Bedford Highway interceptor.
- (18) Duffus Street, 3048 mm combined sewer outfall pipe that carries the flow from the Bedford Highway interceptor.
- (19) Fairview Cove, 305 mm storm and overflow pipe discharges the wet weather flow from the Bedford Highway interceptor.
- (20) Kearney Lake Road storm and overflow pipe, which services parts of Fairview.
- (21) Armdale rotary, 2,438 x 1,219 mm carries wet weather overflow from Armdale pumping station.
- (22) Northwest Arm, 1,219 mm combined sewer services a large area on the west side of the Arm, close to the Armdale Rotary and discharges at Point Pleasant Park.

Dartmouth:

- (1) Tufts Cove, 610 mm combined sewer which services Shannon Park.
- (2) Ferguson Road, 1,016 mm combined sewer that discharges to Tufts Cove.
- (3) Windmill Road, 610 mm overflow services a section of the waterfront.
- (4) Grove Street, 381 mm which services a section of the Dartmouth waterfront. The effluent is being discharged on shore and 10 meters from the closest resident.
- (5) Jamieson Street, 1,219 and 381 mm combined and overflow pipe, respectively, services a tributary area from Windmill Road to Kingston Crescent.

- (6) Lyle Street, 610 mm sewer pipe services a small area from Payzant Street to Lyle Street. The pipe discharges the effluent two meters from the shoreline, adjacent to a scrap yard.
- (7) Best Street to Shore Street, 610 mm sewer pipe that services a small area.
- (8) Geart Street, 457 mm services just one street, Geart Street.
- (9) Park Avenue, 610 and 1,077 mm sewer pipe services a small section of Dartmouth.
- (10) Park Avenue, 533 mm pipe receives storm runoff from Park Avenue area.
- (11) Church Street, 152 mm overflow pipe from the Alderney Drive area.
- (12) North Street, 914 mm combined sewer which services Downtown Dartmouth.
- (13) Alderney Drive, 194 mm which services a small area close to the Dartmouth Shipyard.
- (14) Alderney Drive, 381 mm pipe which is probably an overflow sewer.
- (15) Canal Street, which services Canal Street.
- (16) Dartmouth Cove, 1,524 mm which services a large area from Dartmouth city boundaries to Maitland Street.
- (17) Dartmouth Cove, 122 mm which services an area by Old Ferry Road.
- (18) Tupper Street, 229 mm combined sewer pipe which services a small area from Pleasant Street to Harbour Street.
- (19) Pleasant Street, 254 mm which services from Mount Hope Avenue to Johnstone Avenue.
- (20) Mayfield Drive, 102 mm which services Estates Road and Atlantic Street.
- (21) Melva Street, 406 mm which services a small section of Dartmouth south close to the refineries.

A 508 mm pipe carries the effluents of the Texaco Refinery.

A 610 mm pipe carries the treated effluents from the BIOX plant of the Imperial Refinery, the average flow through this pipe was 12,000,000 liters/day.

A 1219 mm pipe carries an averages of 14,000,000 liters/day of cooling water from the Imperial Refinery.

A 1066 mm pipe carries a total flow of 4,000,000 liters/day of effluent from API separators of the Imperial Oil Refinery.

A 760 mm pipe carries the sewer effluent from Eastern Passage wastewater treatment plant into the Harbour.

A 915 mm pipe carries the sewer effluent from Mill Cove treatment plant into the Bedford Basin.

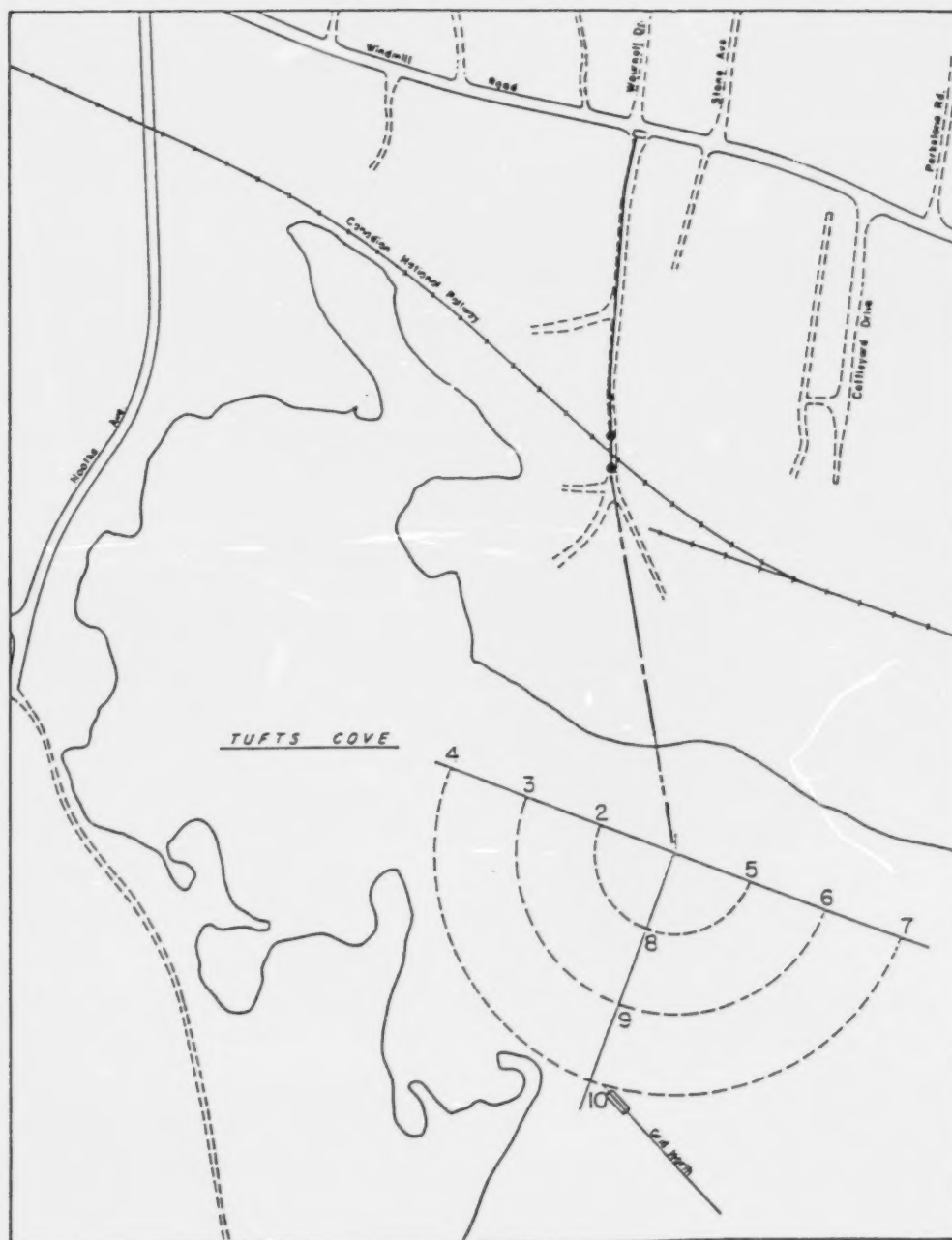
Several establishments discharge their cooling water directly into the Harbour. (e.g. Nova Scotia Power Corporation, refineries and others.)

3.1 Tufts Cove

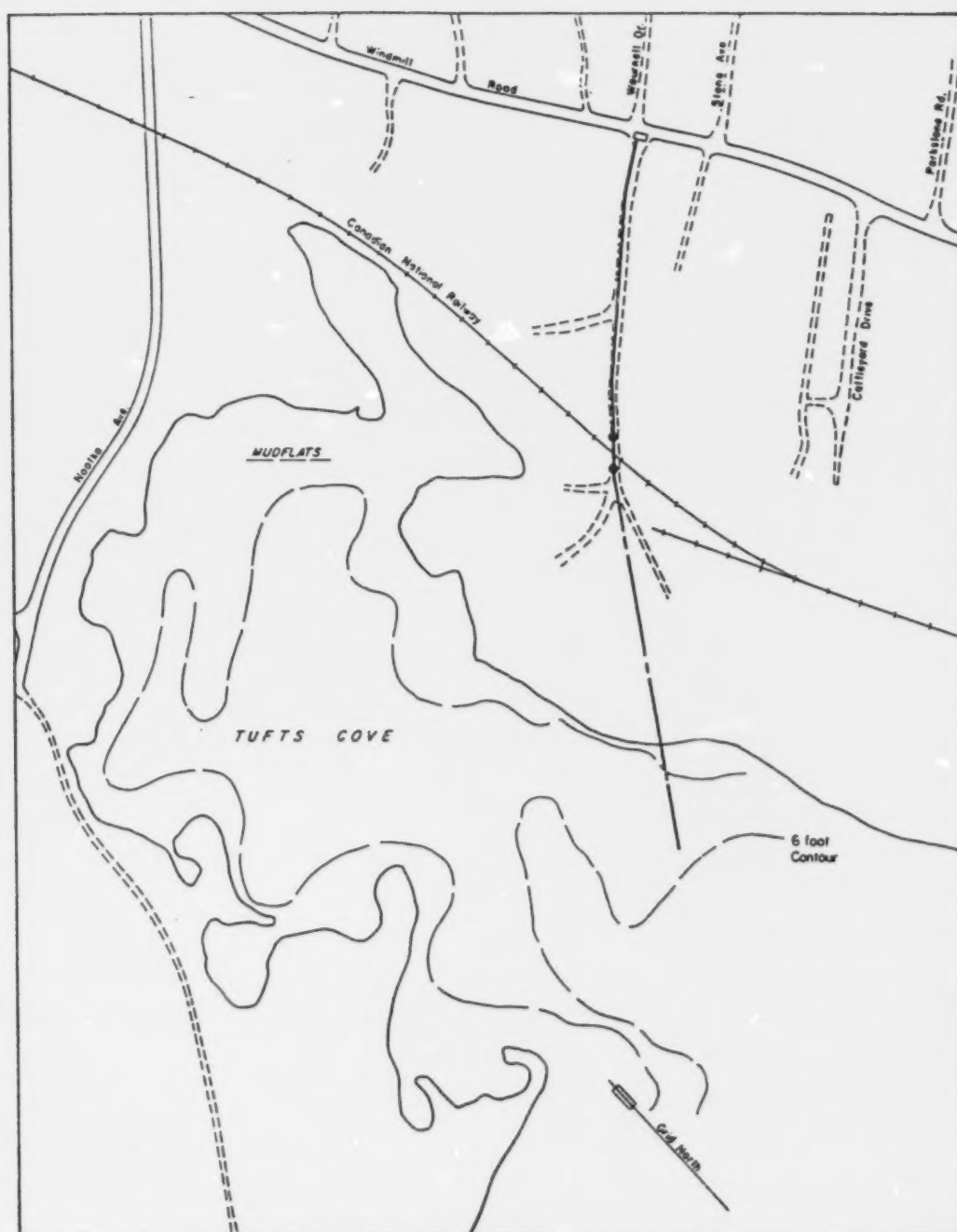
This shallow cove is located in the northern section of the Harbour on the Dartmouth side. The sewer pipes service an approximate population of 3,500 (MAPC, 1984) including the residences of Shannon Park. There is an influx of commuters into the Burnside Industrial Park during the working hours that is not reflected in the estimated population.

Originally, three sewer pipes, serviced the tributary area and discharged into the Cove. Presently, a 1,219 mm pipe services residential, light industrial and light commercial establishments, plus warehouses located in the Burnside Industrial Park and Upper Windmill Road. A 1,067 mm pipe services a residential area of Shannon Park (military housing). From this 927.5 Ha of the tributary area, nearly 65% is developed. There are major highways within the catchment area.

The Ferguson Road sewer discharges at a distance of 2 m from the shore at the mean depth of 80 cm. The rock and cement embankment concealing the sewer pipes, is exposed at low tide. The cove is extremely shallow, to the point that at low tide sampling stations 2, 3 and 4 are inaccessible by boat. The sampling stations were located at radial distance of 50, 100, 150 meters from the discharge point (Map 3-2) and the sewage sample was collected from the last manhole located at Ferguson Road.



Map. 3-2 Sampling Stations at Tufts Cove.



Map 3-3 Bathymetry(feet) at Tufts Cove

The shoreline is characterized as rocky with mud flats. Industrial and housing units are within close proximity of the plume area. The Nova Scotia Power Corporation Electrical Generating Station metal wharf conceals a storm overflow pipe.

Tufts Cove reaches the maximum depth of 10 meters close to the entrance to the cove. The mean depth is 1.8 meters (Map 3-3).

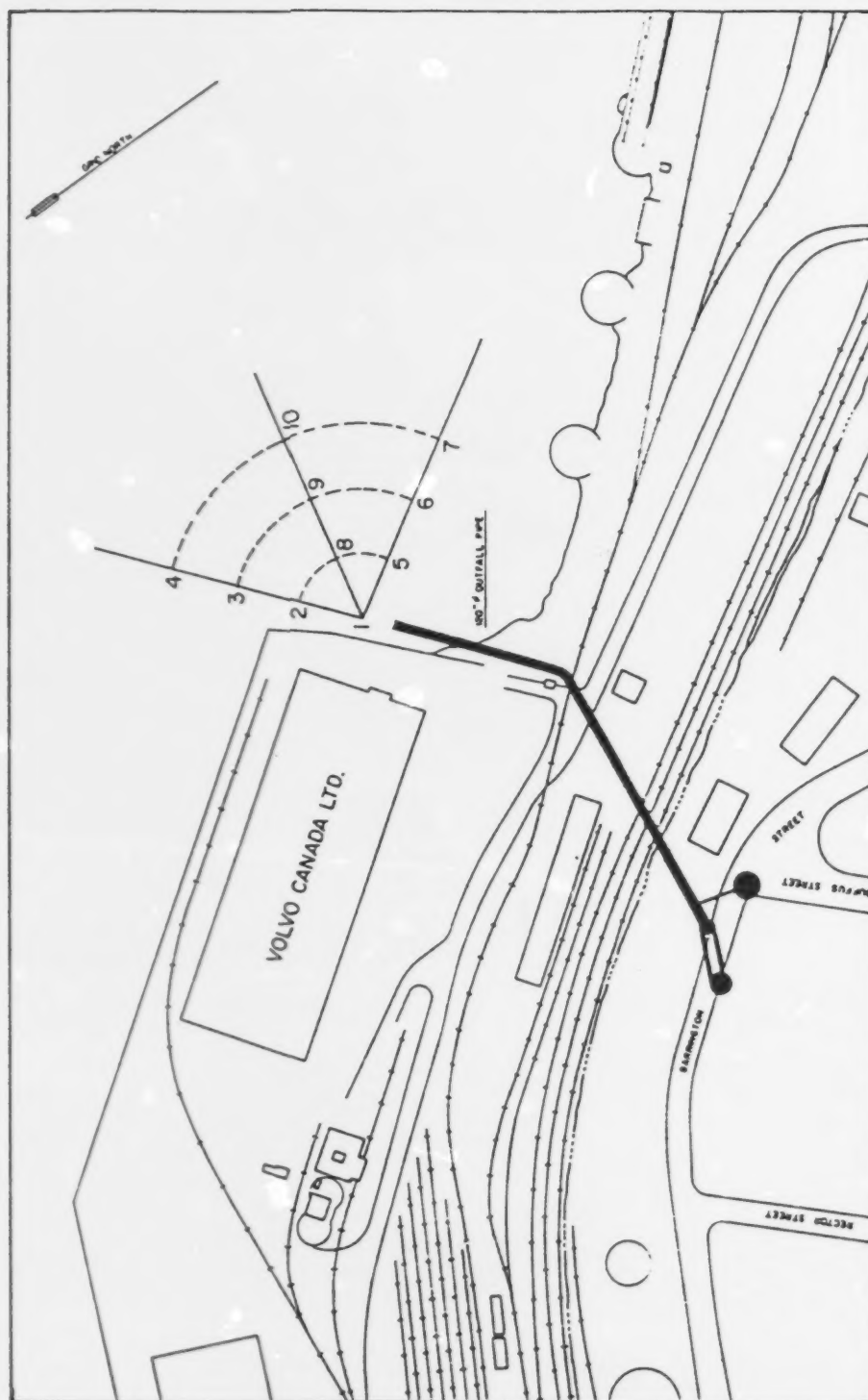
3.2 DUFFUS STREET

The Duffus Street sewer outfall is located on the Halifax side of the Harbour. The Volvo Assembly Plant is on the wharf in close proximity of the pipe outfall.

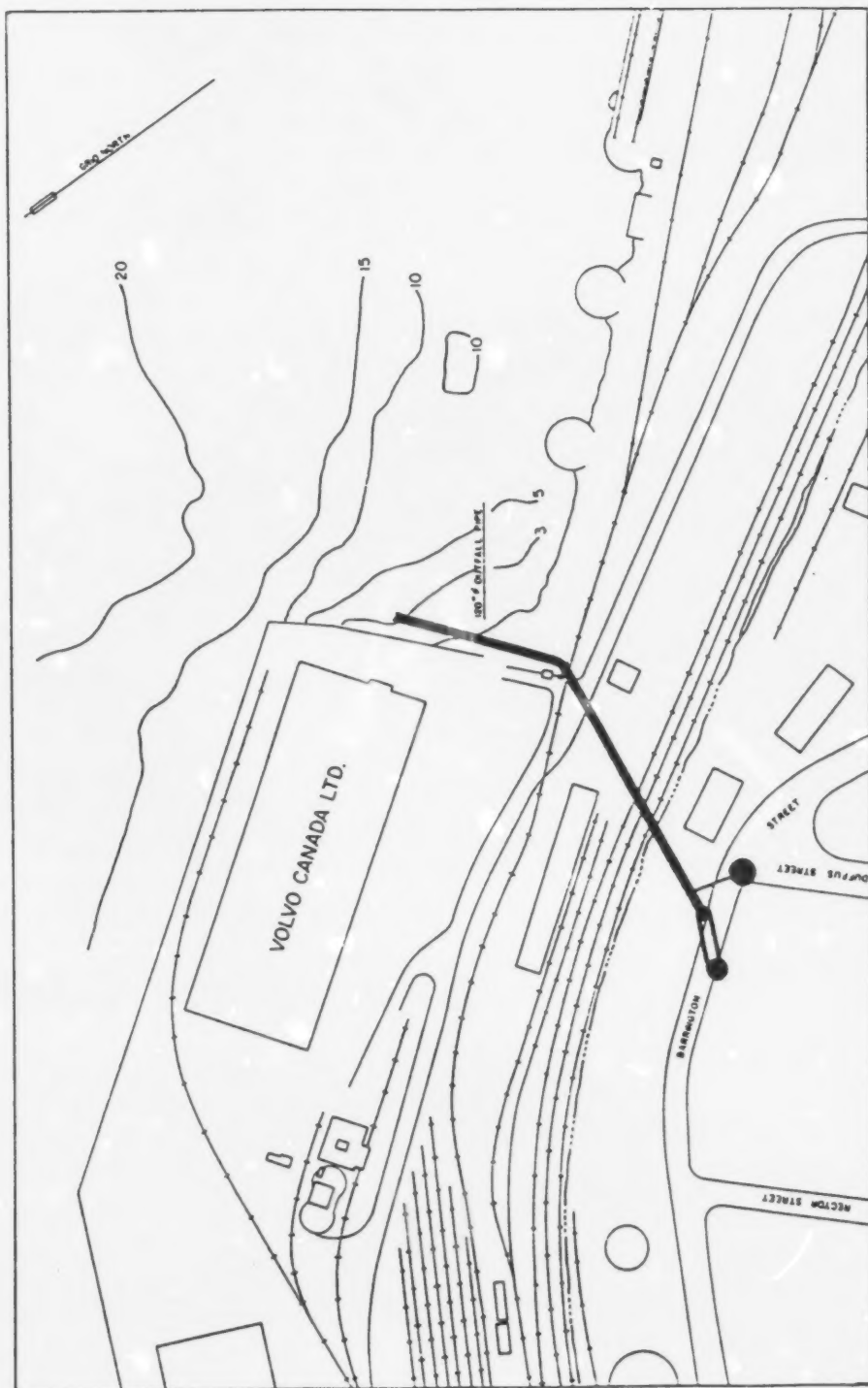
The Duffus Street sewer outfall carries the sewage from a catchment area of 16,625 Ha. and an approximate population of 55,300 (Census, 1984). This 3,048 mm pipe discharges the effluent a meter from shore at a mean depth of 2.5 meters.

The Bedford Highway Interceptor Trunk receives discharges from a rather diverse tributary that consists of three distinct sections: a) the northern most section of the Peninsula which is 100% developed, b) the southern section of the Bedford Highway which is 74.7% developed, with a large number of new housing developments and c) the section beyond the Northwest Arm that has recently joined Halifax's sewerage system. The Bedford Interceptor Trunk collects wastewater from a very vast tributary area. Therefore, there are several pumping stations involved in this collection system, of which, six pumps are located at the last manhole before the discharge point. A portion of the tributary area is serviced by gravity flow sewers.

The catchment area contains shopping malls, a university, hotels, motels, office buildings, garages, assembly plants, a dry dock, a shipyard, a railway yard, a container yard, plus several single and multiple housing developments. The undeveloped sections of the catchment area are lightly forested with a number of highways present.



Map 3-4 Sampling Stations at Duffus Street.



Map 3-5 Bathymetry at Duffus Street(m)

The sampling stations were at radial distances of 50, 100 and 150 meters from the discharge point (Map 3-4). The manhole sample was obtained from the pumping station at the foot of Duffus Street. The maximum depth of the sampling area was observed to be 20 meters with a mean depth of 9.6 meters (Map 3-5).

The plume area is surrounded by a rocky shoreline that is bordered by wooden and concrete wharves, asphalt surfaces and railroad tracks. The wooden and concrete wharf supports the front section of the Volvo Assembly Plant where its dining area is located. Dry dock facilities of Halifax Industries are in the southern section of the plume area. The residential area along Barrington Street is only 200 meters away from the sewer outfall. The employees of both Halifax Industries and the Volvo Assembly Plant are always in close proximity of the sewer outfall area.

The Duffus Street plume area is deep, providing a large amount of dilution and dispersion of the effluents. The effluent discharged to the area almost always appears to move towards the middle and south of the Harbour. A high level of dissolved oxygen was observed during the study period, which supports the fact that a large amount of current and tidal activities exist within the area.

3.3 Dartmouth Cove

Dartmouth Cove is located at the southeastern section of the Harbour. The sewers that discharge to the Cove service an approximate population of 71,000 (Census, 1984) and a tributary area of 1,515.5 Ha. of which 63.8% of the area is developed. The Cove receives the effluents from:

- a) Dartmouth shipyard via a 910 mm pipe;
- b) a 763 mm pipe which services a small area close to Old Ferry Road; and
- c) a 1,524 mm sewer pipe which collects the wastewater from a large tributary area of 1,307.5 Ha.

The sewer pipes from Maitland Avenue and the shipyard discharge their effluent at one point, while the Old Ferry Road sewer pipe discharges at another site close to the Canadian Coast Guard Base.

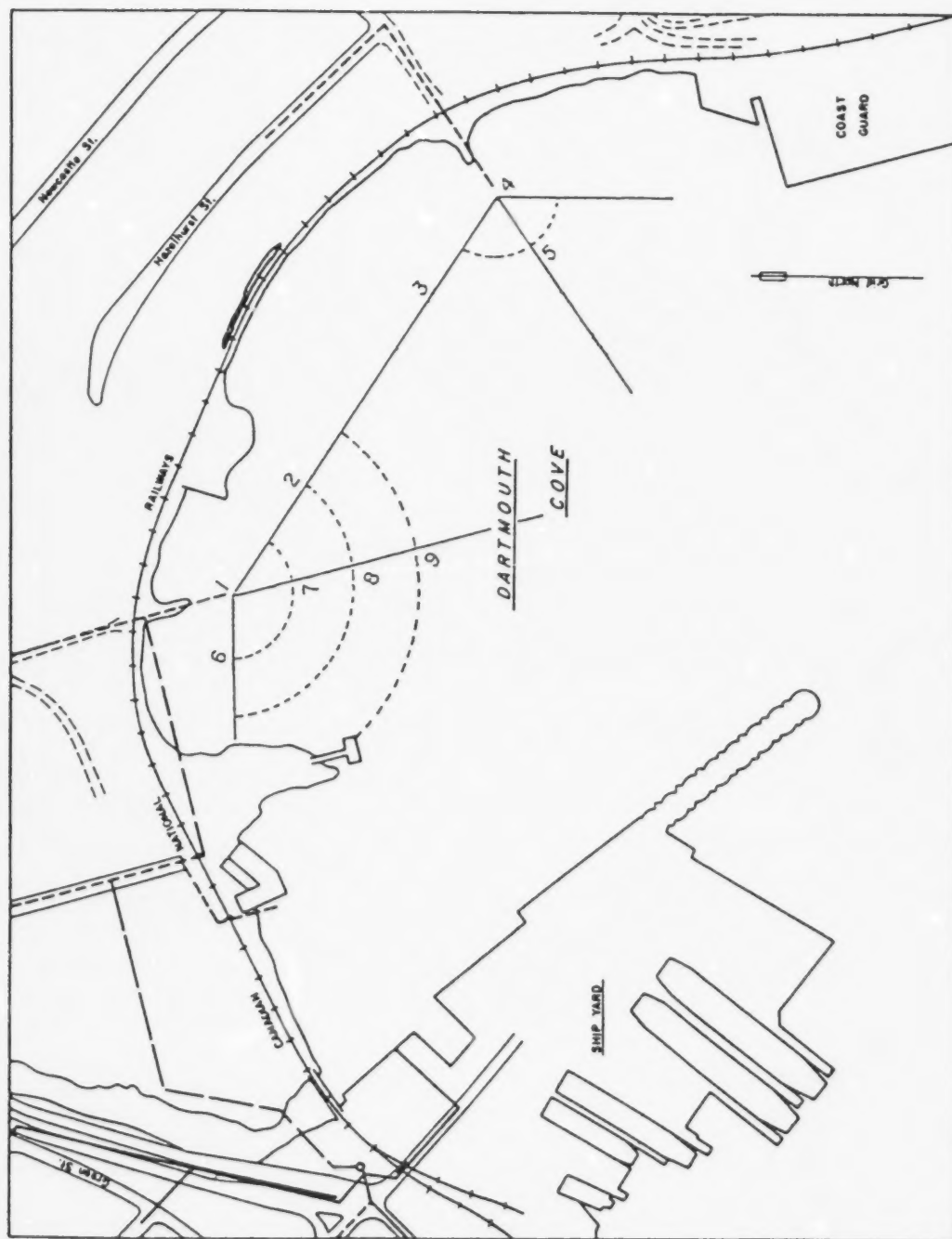
The sampling stations were distributed throughout the Cove at radial distances of 50, 100, 150 and 200 meters from the outfalls (Map 3-6). The emphasis of the study was on the Maitland Avenue sewer outfall, as a result more stations were situated around this discharge point. This sewer outfall discharges the effluent in the vicinity of two shipwrecks, at a distance of 2 meters from the shore and at a mean depth of 1.5 meters. The wastewater from the Old Ferry Road sewer discharges approximately 1.5 meters away from the shoreline at a mean depth of 80 centimeters.

The shoreline of Dartmouth Cove is generally rocky, on which is situated the Canadian Coast Guard Base, residential homes, the Dartmouth Shipyard, railroad tracks and warehouses. Housing units are only 10 meters from the discharge points.

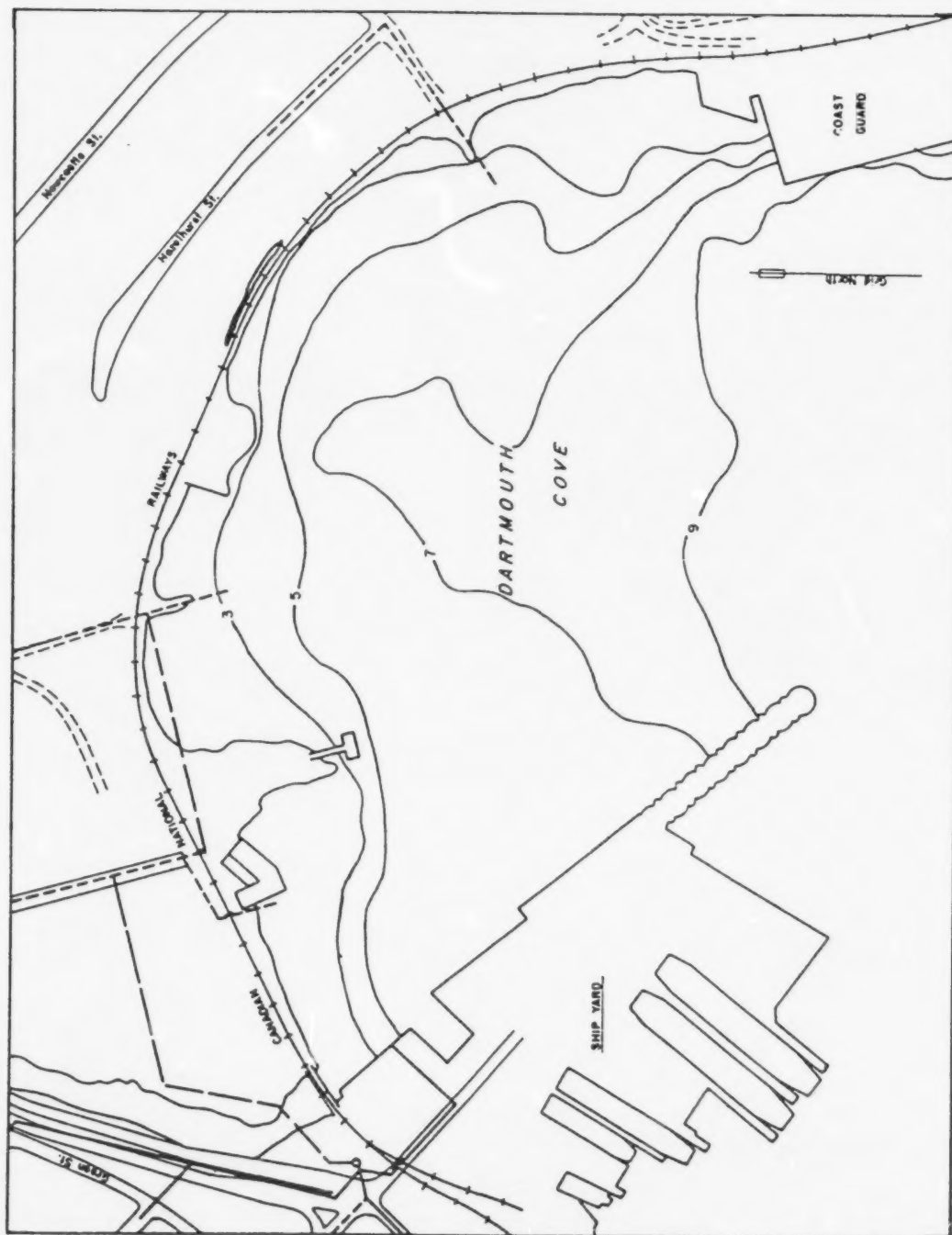
The land use activities in the tributary area are very diverse and consist of residential, light and heavy industrial, institutional and commercial areas. There is also a research facility, several schools, small industry, heavily commercialized areas, single and multiple housing units which are scattered in the tributary area. Undeveloped sections of the area contain several lakes (Penhorn, MicMac, Banook and Charles) and forested areas in the northern section. The area is also serviced by several large highways and a rotary.

The bathymetry, is such that large ships are able to dock within the Cove at the Dartmouth Shipyard and Canadian Coast Guard Base and there are also boats buoyed within the Cove. The maximum depth of the sampling stations was 9.0 meters and a mean depth of 5.0 meters (Map 3-7).

The outfalls are located in the shallowest part of the Cove, in the northern and eastern sections. A severe case of waste accumulation can be observed in the northern section near the shipwrecks.



Map. 3-6 Sampling Stations at Dartmouth Cove



Map 3-7 Bathymetry(m) at Dartmouth Cove

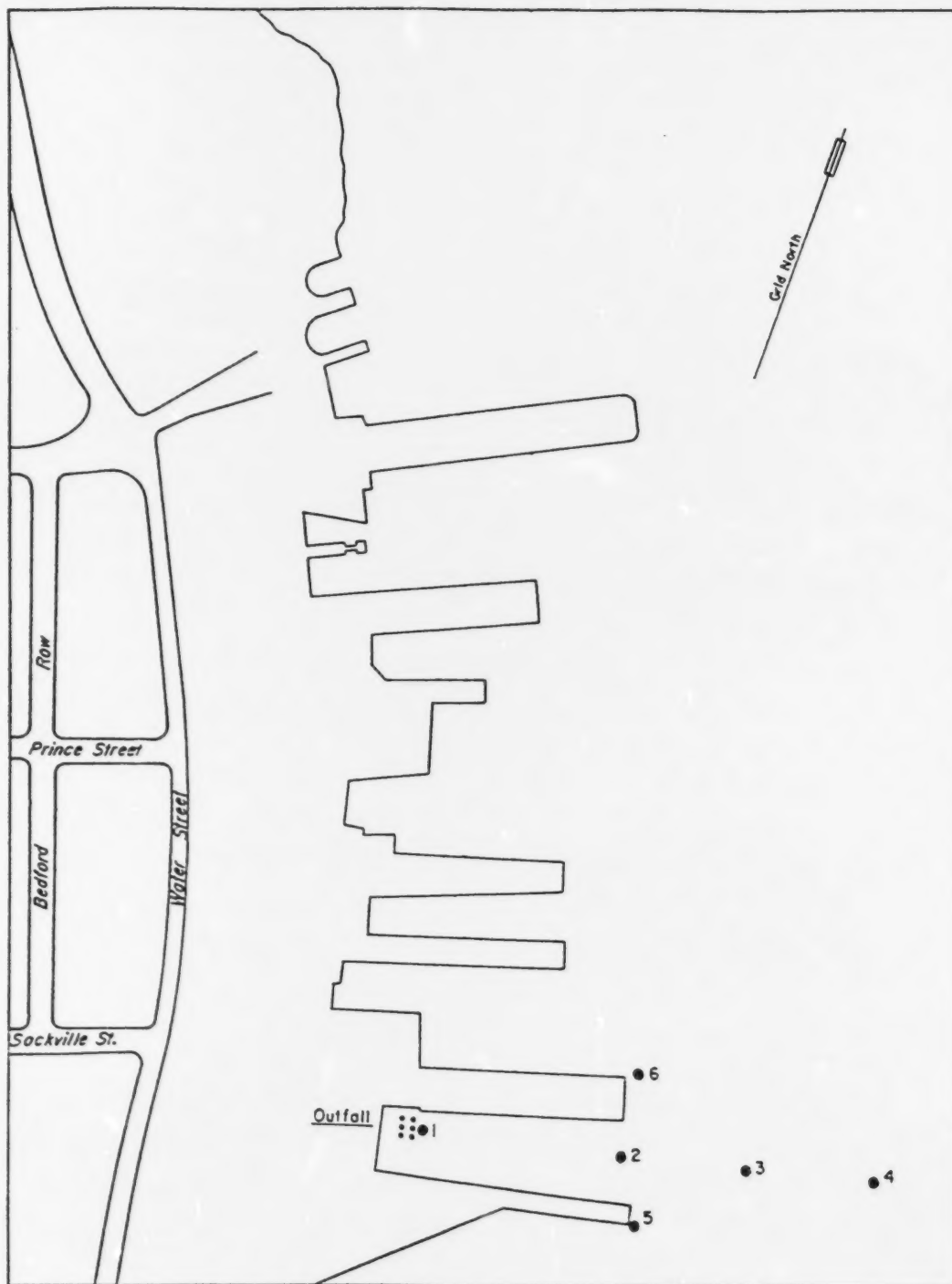
Dartmouth Cove appears to be affected partially by tidal and current activities. The open and deeper section, close to the Coast Guard Base, was observed to mix more regularly than the section that was near the shipyard. The dilution/dispersion was rather stagnant close to the northeastern section of the Cove. The adequacy of the level of dilution is questionable.

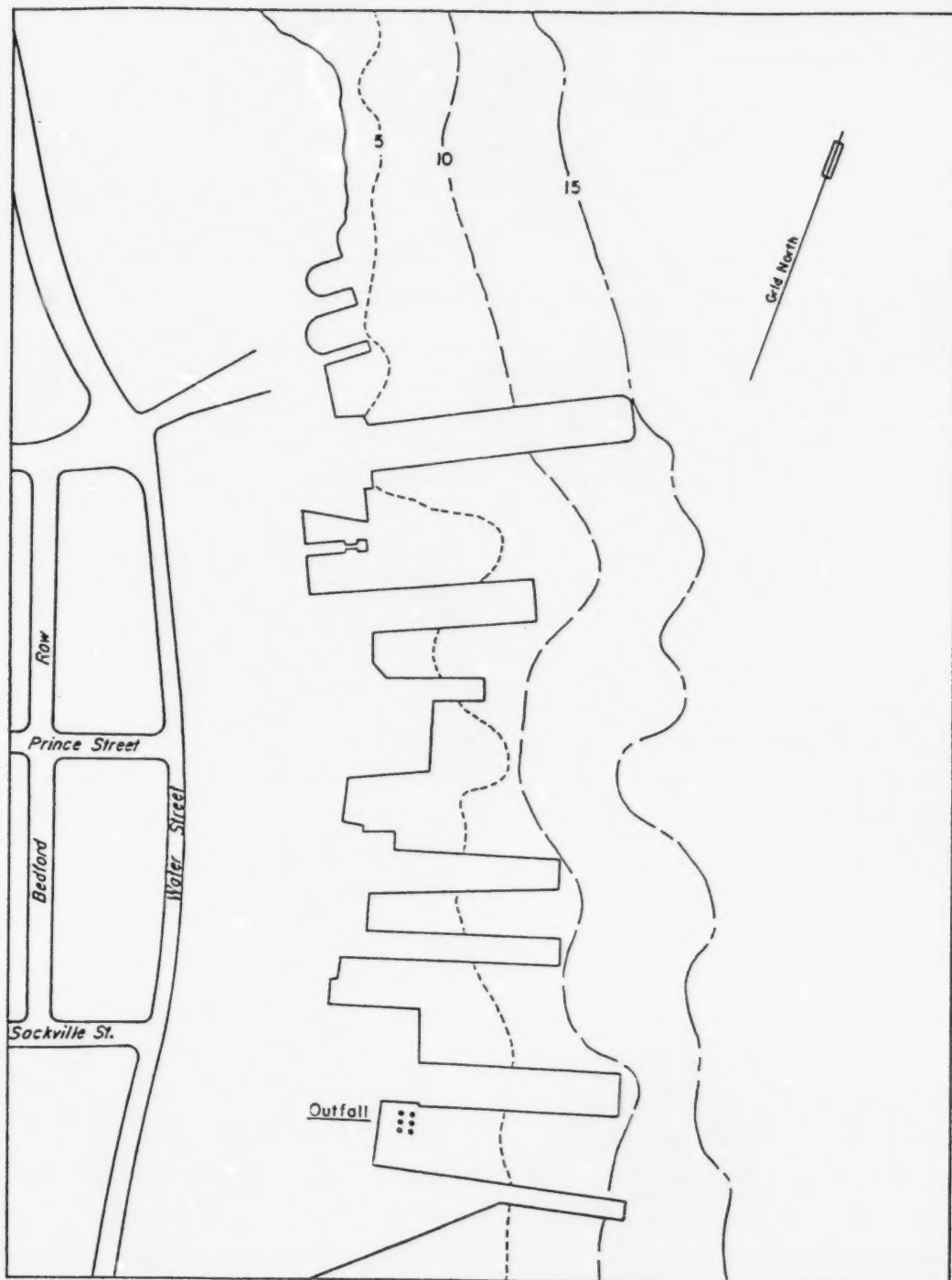
3.4 SACKVILLE STREET

The Sackville Street outfall area consists of a series of wooden wharves that provide docking space for tour and pleasure boats. The sewer outfall is located at the southwestern section of the Harbour, on the Halifax side. The Sackville street sewer trunk receives its effluent from central Halifax, while other sections of the downtown core discharge their sewage through other outfalls. The 1.83 meter trunk carries the wastewater from 87.5 hectares of tributary area, which is approximately 100% developed. The serviced area has an approximate population of 9,000 (census, 1984) plus an influx of commuters to the catchment area during the working hours.

Four 1,020 mm pipes, discharge the sewage at the bottom section of the wooden supports and the outfall pipes are located at a mean depth of 2.1 meters and nearly 1.5 meters from the shoreline. Sackville Street sewer discharges between two wooden wharves. Hence, there is movement of seawater through the wharves. Sampling stations were situated in a straight line out from the plume, at distances of 75, 100 and 150 meters and there is a sampling station located at the end of each of the two wharves (Map 3-8). Sewage samples from Sackville Street trunk were collected at the last manhole located on the corner of Sackville and Lower Water Street.

Parallel to Water Street there is a very large parking lot adjacent to the wharves. There are several office buildings, a shopping area and a museum located on the shoreline. There are very few housing units in the area. However, there is a considerable amount of human traffic within the vicinity of the outfall at all times especially during the tourist season.





Map 3-9 Bathymetry (m) at Sackville Street

The tributary area is predominantly residential with a large amount of commercial and institutional activities present. There is a hotel, a hospital, schools and a commercial section of Quinpcol Road which is serviced by this sanitary trunk. Commons Park is also located in watershed area.

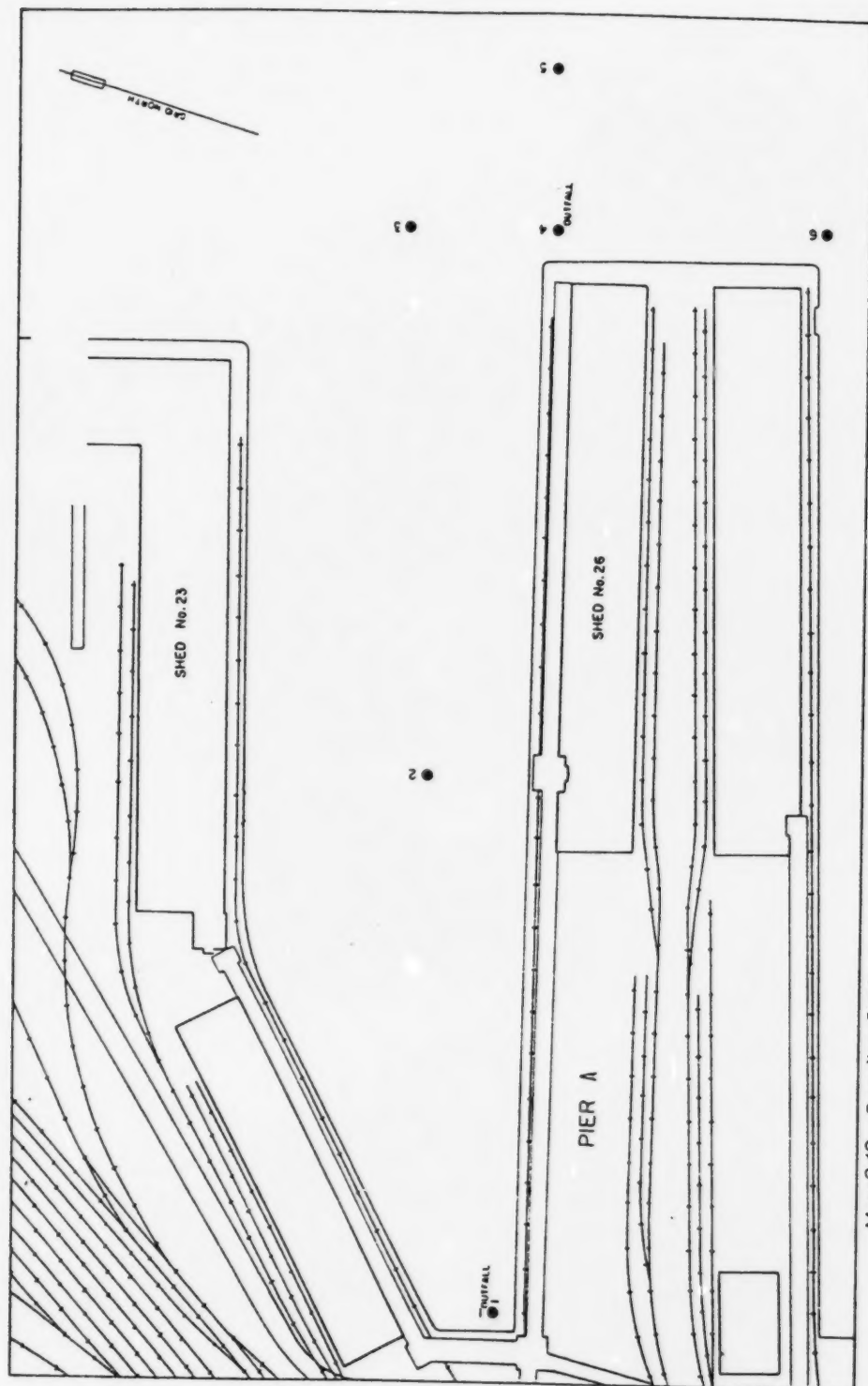
Bathymetry of the outfall indicates a maximum depth of 18 meters and a mean depth of 11.3 meters (Map 3-9).

The turbidity was high at every sampling station , regardless of the depth of the outfall. In the case of Sackville Street plume area, the depth and exposure had no bearing on the level of dilution and dispersion.

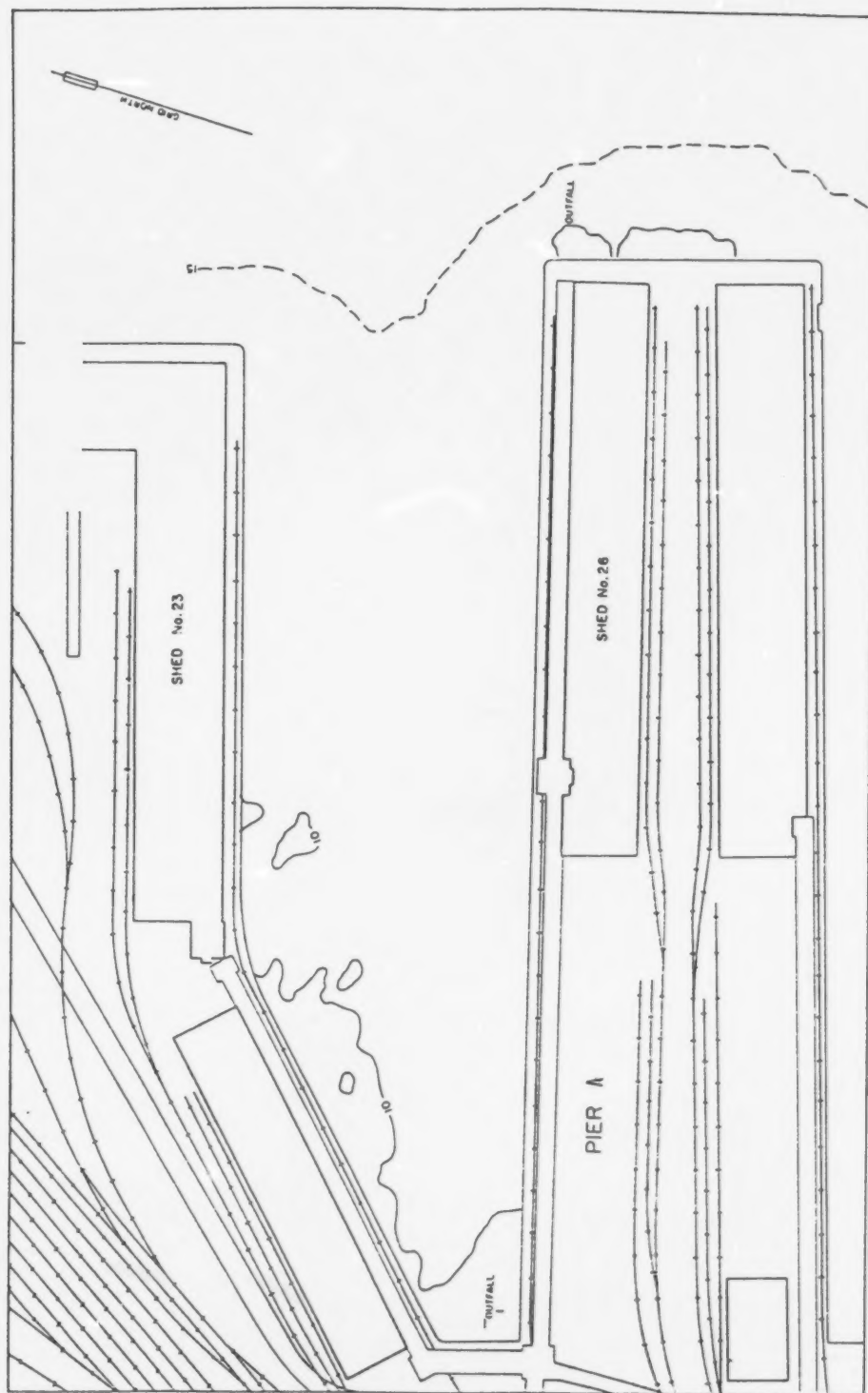
3.5 PIER A

Pier "A" is located in the Port of Halifax which is in the southwestern part of the Harbour. Shed 23 and 26 are on either side of this body of water that receives the effluents from a sewer tunnel and a sewer overflow pipe. The sewer tunnel, known as "Old freshwater brook", has the dimensions of 3,353 x 1,524 mm. It had been constructed nearly 100 years ago and recently a 914 mm overflow pipe was added to the system. The sewer tunnel discharges in the waters of Pier "A" and the overflow pipe at the end of the pier. The "Old freshwater brook" sewer services an area of 483 Ha. with an approximate population of 17,000. A substantial number of people commute into the catchment area during the working and school hours. The south end of Halifax is nearly 100% developed.

The sampling stations 1, 2, and 3 are located at the plume, adjacent to the grain loader and at the entrance to the Pier. Station 4 is at the overflow pipe discharge and station 5 is towards the middle of the Harbour 50 meters from station 4. Sampling station 6 is located 100 meters away from station 4 at the other end of the pier (Map 3-10). Manhole samples were obtained from a site located at the end of Barrington Street. The trunk and the overflow pipe discharge their effluents at the mean depths of 3 m and 0.5 m, respectively. The maximum depth of the plume area is 18 meters with a mean depth of 9.3 meters (Map 3-11).



Map 3-10 Sampling Stations at Pier A



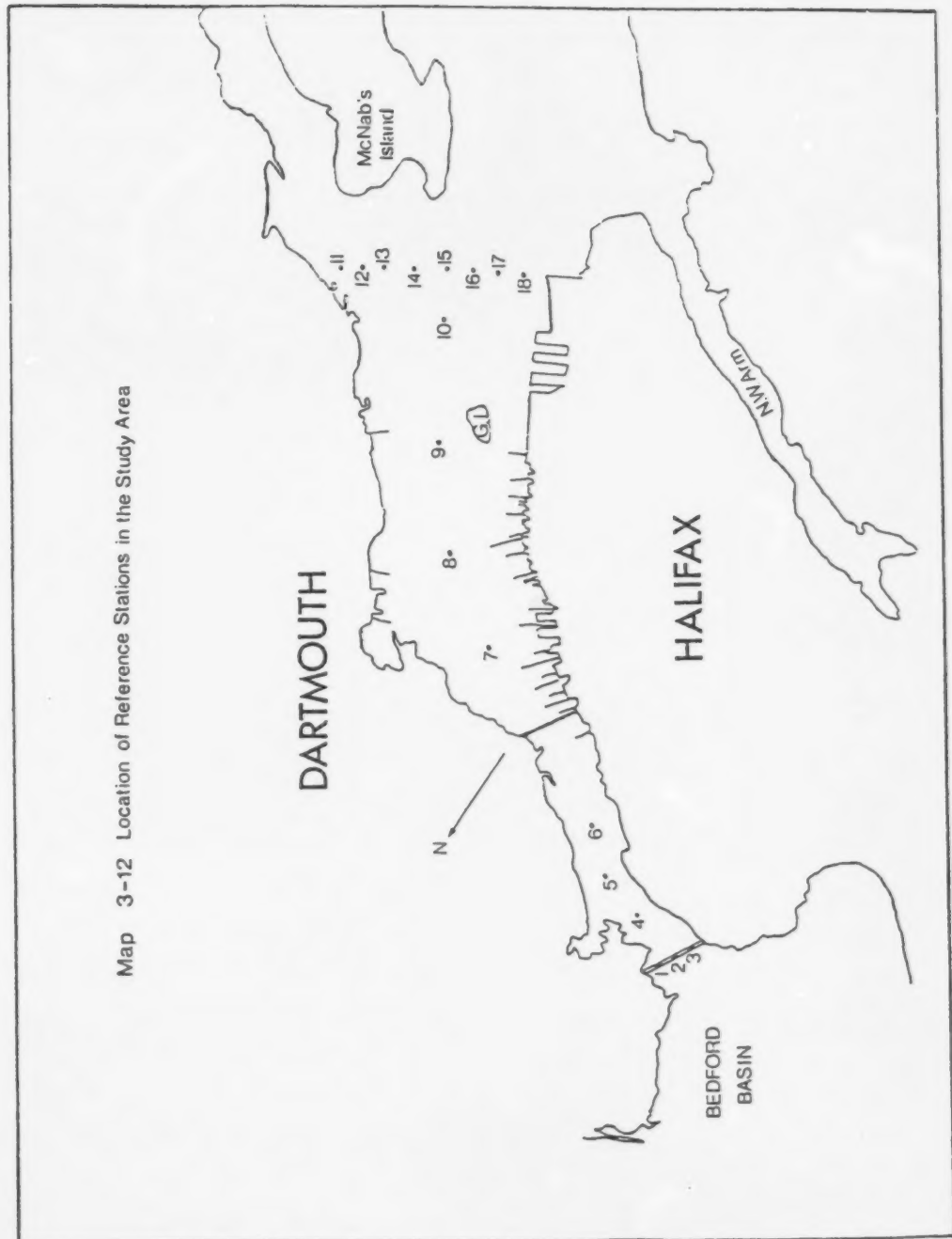
Map 3-11 Bathymetry(m) at Pier A

The catchment area is fully developed with a container yard, grain elevator, commercial areas plus a high concentration of residences and institutions. A large section of the tributary area is allocated as a park (Point Pleasant) plus several hospitals and two universities, office buildings laboratories, medical research establishment and shopping facilities are present.

The Pier "A" area contains warehouses, equipment sheds, railroad tracks and a grain loader. There is continuous movement of ships into the plume area. The concrete walls around the plume reduce the movement of the seawater into the plume area. As a result of the continuous flow of wastewater and low flushing activity the plume area is highly septic and aesthetically unpleasant. The tidal and current activities have little effect in flushing the plume area.

3.6 Reference Sites

Location of the reference sites in Halifax Harbour were within the region of MacKay Bridge to MacNabs Island and another reference site was located outside this region, off the coast of Nova Scotia. The reference stations were located in three distinct sections of the Harbour. a) Three sampling stations were located under the MacKay Bridge and 100 meters apart from each other. b) Seven stations were located in the middle of the Harbour. These sites were situated such that a site was located before and after each sewer outfall area, for example station 4 was located before Tufts Cove and station 5 immediately past the entrance to the Cove. This provision had been made for every reference site situated in the middle of the Harbour. c) Eight sites were located in the entrance to the Harbour. These stations were at a distance of 267 meters from each other in a straight line between the shorelines of Imperial Oil Refinery on the Dartmouth side and Point Pleasant Park on the Halifax side (illustrated Map 3-12). This line is known as a "crossing line" by the Halifax Queen Harbour Master. The reference site outside the Harbour was located at $43^{\circ}.09'.70''$ N and $63^{\circ}.37'.10''$ W off the coast of Nova Scotia. Both surface and bottom were sampled at each reference site.



Map 3-12 Location of Reference Stations in the Study Area

Since the sampling sites were distributed over a distance of 8.0 km, the station depths were variable. 1) Stations 1 through 3 have a mean depth of 12.6 meters, 2) stations 4 to 10 are 17.8, 15.6, 14.8, 15.0, 16.2, 17.8 and 22 meters deep respectively. 3) Stations 11 to 18 are 19.5, 22.3, 20.6, 21.0, 15.7, 27.1, 26.2 and 22.4 meters deep, respectively.

Even though Halifax Harbour has variable widths, the reference stations were situated equidistance from either shoreline in the middle of the Harbour.

The shorelines of Halifax Harbour are predominantly made up of man-made structures and filled in areas, with rocky shorelines and small sections covered with sand and mudflats, which aid in dispersing the effluents to mid-harbour. In the immediate vicinity of the Harbour shoreline and within the watershed area, a high concentration and a diverse level of residential, commercial, industrial and institutional activities are present.

The reference stations were selected to allow monitoring of the waste movement from either shoreline to the middle of the Harbour, as well as the transport of sewage into the Basin or towards outside the Harbour. It was also attempted to study possible transportation of various contaminants from Bedford Basin into the waters of the Narrows. Halifax Inlet is being flushed at a rate of 3 to 5 days by tidal and current activities (Lewis and Platt 1983). There are also other mechanisms that displace the Harbour waters such as intrusion of cold and saline waters from the Scotian Shelf. The magnitude of the impacts and amplitudes of the tides and offshore currents effecting the Harbour waters will be discussed in detail in Section 5.4.

Section 4.0 Data Collection Procedures

This section of the report presents a description of the data collection program conducted during the monitoring period. The research investigation consisted of the following seven areas of data gathering:

- 4.1 Marine waters were sampled at five sewer outfalls and at reference sites. Sewage samples were obtained from a manhole before the point of discharge at the five respective sewer outfall sites.
- 4.2 Tests conducted in the field for water quality parameters were
 - 4.2.1 Temperature,
 - 4.2.2 Dissolved Oxygen,
 - 4.2.3 Salinity,
 - 4.2.4 Conductivity and
 - 4.2.5 Transparency.
- 4.3 Wastewater quality testing performed on marine waters and sewage samples, were assayed in the laboratories of the Nova Scotia Department of the Environment and Victoria General Hospital for the following parameters:
 - 4.3.1 Chemical Oxygen Demand,
 - 4.3.2 Biochemical Oxygen Demand,
 - 4.3.3 Suspended Solids,
 - 4.3.4 pH,
 - 4.3.5 Total Coliform (VGH),
 - 4.3.6 Faecal Coliform (VGH),
 - 4.3.7 Total Plate Count (VGH),
 - 4.3.8 Staphylococcus (VGH) and
 - 4.3.9 Pseudomonas (VGH).
- 4.4 Laboratory testing of seasonal samples obtained from a reference point, 43°09'.70" N and 63°37'.10" W, off the coast of Nova Scotia.
- 4.5 Recording of Meteorological conditions on land and water were recorded during the sampling period.

- 4.6 A daily record of water levels in the Harbour was recorded. The gauge readings were documented for every fifteen minutes of the sampling day.
- 4.7 Halifax Harbour traffic data was collected on a weekly basis for the duration of the monitoring program.

4.1 Marine and Wastewater Sampling Program

Sewer outfalls located at Duffus Street, Tufts Cove and Dartmouth Cove were sampled regularly and frequently for the period of September 1984 to August 1985, inclusive. Sackville Street and Pier "A" outfalls were included in the sampling program during the second period of monitoring from February to August 1985. The reference stations both inside and outside Halifax Harbour were monitored on a specific day in the fall, winter, spring and summer. Details of the sampling stations and physical description of the sewer outfalls have been presented in Section Three. The following sites were also sampled: Historic Properties, Oland's (Young Street), Mill Cove and Eastern Passage sewage treatment plants effluent, North and Jamison Street outfalls and the Sackville River discharge.

Water samples were collected using a Kemmerer 1.2 litre water and wastewater sampler. Samples were bottled in 2.0 liter polyethylene containers and capped tightly for transportation, bacteriological samples were bottled in eight ounce glass bottles.

Eighteen reference sites were selected for sampling. From these eighteen sites: three stations were under MacKay Bridge, seven stations were located in the middle of the Harbour and eight stations were located across the entrance to the Harbour from Point Pleasant Park to the Imperial refinery. Reference samples were collected from the surface and at the depth of ten meters. In addition to the reference stations within the Harbour, another site outside the Harbour was monitored.

A total of 138 days of sampling was conducted, over a period of eleven months (45 weeks). From this total, 30 days of sampling were conducted for each site at Duffus Street, Tufts Cove and Dartmouth Cove. Pier A and Sackville Street were each sampled 18 times. The reference sites were sampled four times, once every season. Effluents discharged from Historic Properties and Oland's (Young Street) sewer outfalls were tested once a month in the summer of 1985. Mill Cove and Eastern Passage were visited once in winter, spring, and summer. The discharges from Sackville River, Northwest Arm and Dartmouth outfalls were sampled once. North Street, Albrow Lake Road and Grove Street sewer pipes constitute the sewer outfalls in Dartmouth.

The sampling program was set up such that each of the major sites was visited on a weekly or a biweekly basis. A sewage sample was collected from a manhole just before the point of discharge at each of the five major outfalls. In the case of the reference sites, sampling was conducted on the second month of each season, except for the winter of 1985.

Marine and sewage samples were collected and analyzed the same day. Bacteriological samples were collected on a monthly basis, and were sent for analysis to the VGH the same day. In the case of spills and unusual discharges the samples were sent to the pathology lab or Environmental Protection Services (EPS) for various tests.

A sum of 3,874 samples were collected from the five major outfall sites. There were 148 reference samples collected and analyzed. A total of 122 samples were obtained from the Dartmouth outfalls, sewage treatment plants, the Sackville River and the Northwest Arm. Therefore, a total of 4,144 sewage and marine water samples were collected and tested for major wastewater quality over the period of a "Hydrologic Year". Water samples were not collected for the month of January 1985 due to setting up of a Wastewater Chemistry laboratory and devising new experiments. The sampling program was halted for the last week of December 1984 resumed in February 1985 and finally terminated in August of the same year.

4.2 Water Quality Testing Conducted in the Field

A field water quality analysis was introduced to the monitoring program in February, 1985 that coincided with the second portion of the study. The program was set to monitor: Temperature, Dissolved Oxygen, Salinity, Conductivity and Transparency in every meter of the water column for each station. The field monitoring program tested every station of each site within the study area for a period of seven months. From October to December of 1985, only temperature and dissolved oxygen levels were monitored in the field for Tufts Cove, Duffus Street and Dartmouth Cove.

4.2.1 Temperature was measured utilizing the Yellow Spring Instrument (YSI) dissolved oxygen meter model 57. Temperature readings at each station were used to calibrate the Salinity, Conductance and Temperature meter (SCT meter).

4.2.2 Dissolved Oxygen was measured by electrometric method, using a field membrane electrode. A Yellow Spring Instrument model 57 dissolved oxygen meter was utilized in the field. The DO meter was calibrated daily against the oxygen level detected by the Winkler Method (modified azide technique). To detect and quantify possible changes or mishaps during the field monitoring session, the DO meter was calibrated on arrival to the laboratory. Further checks were made by collecting random samples from various depths and stations in BOD bottles. Oxygen content of the samples were fixed by the addition of Manganese Sulphate and Alkalide Iodide Sodium Azide solution to each bottle, in the field. Titration of the samples were completed in the laboratory. Oxygen meter readings deviated +5% from results obtained from iodometric titration techniques. Model 57 Y.S.I. DO meter has a capability of measuring dissolved oxygen in seawater, because the meter is equipped with a device that gauges the salinity and adjusts the level of dissolved oxygen, accordingly. The salinity device on the DO meter was set at 32 PPT to coincide with the average salinity of Halifax Harbour waters.

4.2.3 Salinity measurements were carried out utilizing a Yellow Spring Instrument model 33 salinity, conductivity and temperature meter. Calibration procedure was according to the argentometric technique of Standard Methods, 1975. The SCT meter was further tested against samples with known salinity on a regular basis. The probe of the S.C.T. meter was cleaned and flushed with deionized water daily.

4.2.4 Conductivity of sewage-seawater samples was measured using the YSI 33 SCT meter. The calibration and cleaning procedures were as those carried out for salinity.

4.2.5 Transparency of the seawater was tested using the Secchi Disc. A 20 cm disc with alternate black and white quadrants was utilized to read the visual transparency of the plume waters.

4.3 Wastewater Quality Tests Performed in the Project Laboratory

Analyses of the water quality parameters such as: Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Suspended Solids (SS) and pH were performed in the laboratory which was set up for this monitoring program. Bacteriological testing of the outfall samples as well as Total Organic Carbon (TOC) of spills was conducted by the Environmental Chemistry Department (Victoria General Hospital, VGH). There were also some toxicity assessments of the spills that were performed by the Environmental Protection Services (EPS) Laboratory.

4.3.1 Chemical Oxygen Demand contamination level was determined by modified potassium dichromate technique as it was described in Standard Methods (1975).

Seawater contains a high level of halogenated molecules that interfere with the COD test. The chloride interference was remedied by dilution of samples as well as increasing the level of

Assessment of chemical oxygen demand had begun in the second portion of the study from April to August 1985, inclusive. COD testing of the samples was implemented since it complemented the values of BOD, and provided the monitoring program with a better measure of pollutants in sanitary and industrial effluents.

- 4.3.2 Biochemical Oxygen Demand levels of the Harbour waters, containing sewage loads; were measured utilizing immediate and Five Day Oxygen Demand Differentiation Method. Oxidative reaction involves the breakdown of nitrogenous and carbonaceous organic matters by microorganisms that survive the severe conditions of cold seawater. The procedure followed was a modification of the technique described by the Standard Methods, 1975.

Samples were diluted from 2 to 80% with dilution water. Dilution water was prepared using deionized water containing micro-nutrients. Dilution water was aerated till the DO was the same as that by the Winkler method, therefore optimum physical and chemical conditions were achieved for the BOD tests. Sample dilutions were conducted nearly 5 hours after aeration and rechecked for the DO level. Conditioned Bacterial seeds were not added to the dilution water because testing did not show an elevated level of bacterial activity and alterations in BOD readings due to the addition of conditioned and unconditioned seed.

Many experiments were set up to test variability in BOD readings due to changes in physical and chemical modifications. It was concluded that the samples contained an adequate microbiological population for oxidizing the organic contaminants present in the samples.

Initial and final dissolved oxygen was measured by a YSI Model 57 DO meter utilizing the adjustment knob for salinity readings. This meter was calibrated daily against the Winkler reading of dissolved oxygen. DO readings below 1 mg/L were omitted and biochemical oxygen demand above 1.0 mg/L was accepted for data analysis.

All the samples were prepared and incubated the same day as they were collected. Hence, no preservation techniques were required. During the cold months, before incubation, the samples were warmed to room temperature by immersing the polyethylene sample bottles in warm water.

Biweekly standard glucose solution was assayed. The results obtained from the quality control solutions were $\pm 20\%$ of the 500 mg/l of BOD in salt and freshwater stocks.

- 4.3.3 Suspended Solid contents of the sewage and seawaters were collected and measured by Filtration Technique using a Milli-Pore set. Five hundred to a thousand milliliters of sample were filtered through 4.7-9.0 cm Whatman Glass Fiber (GF/C) filters. Only 100 ml of the manhole and spill were filtered, since large amounts of suspended matter tends to clog the filter pad.

A slightly modified filtration technique was implemented; two clean filter pads were weighed, dried, cooled and reweighed to measure the difference in weight due to moisture loss.

Testing the samples for the level of suspended matters for all the sites was started in September 1984 and concluded in August 1985.

- 4.3.4 pH of the samples was measured utilizing a D-10 Horiba pH-meter. The pH-meter automatically measured the sample's temperature and adjusted the readings accordingly.

Testing for pH was carried out over the period of September 1984 to August 1985.

- 4.3.5 Total coliform assays were prepared by Membrane Filter Technique as described by the Standard Methods, 1975. The M-Endo Media was used for the growth of the Total Coliforms. An exact count of the microorganisms was not provided. Since samples were not diluted extensively, water samples were gathered in 8 oz. glass bottles.

Bacterial testing was started in April 1985 and a limited number of sites was sampled. The sites selected were in a straight line from the plume, extending towards the center of the Harbour.

- 4.3.6 Faecal coliform samples were also tested using the Filter Technique. The media used for Faecal Coliform testing was M-Fc broth.

The sampling technique and data gathering duration were the same as the Total Coliform test.

- 4.3.7 Total plate count media was used for detection of the density of aerobic, facultative anaerobic and heterotrophic bacteria in the effluent samples.

The method of sampling as well as the monitoring period was the same as for the Faecal and Total Coliform test.

- 4.3.8 Staphylococcus bacterial density was determined utilizing the Multiple Tubing Techniques as outlined in the Standard Methods, 1975. The m-staphylococcus broth was used for bacterial growth and differentiation. The sampling and testing duration were the same as other bacterial assaying.

- 4.3.9 Pseudomonas strains of bacteria were assayed by using the Membrane Filter Technique. The isolated bacteria were maintained in modified M-Pa agar.

4.4 Water Quality Testing of Samples Collected from a Reference Point Outside the Harbour

Once every season a surface sample was obtained from a location outside Halifax Harbour. This reference point was located at the longitude of $43^{\circ}09'.70''$ N and latitude of $63^{\circ}37'.10''$ W off the coast of Nova Scotia. Department of National Defence, Research Division had kindly collected the samples using the assistance of the "Quest" navy vessel.

Two liters of water sample were collected in polyethylene containers. Samples were received for laboratory testing within 24 hours of collection. Therefore, refrigeration was the only means of sample preservation. Routine laboratory testing was carried out for these water samples. Since the reference point samples were not collected by this monitoring group there is no field data available.

Sampling of a reference point outside the Harbour was set to determine the water quality of relatively undisturbed marine ecosystem. These water quality results provided the monitoring program with baseline data on "Background Conditions" of the Harbour waters.

4.5 Record of Meteorological Conditions During the Sampling Period

Meteorological conditions on land and water were recorded during the sampling period. Any excessive precipitation or presence of a storm on the day prior to sampling were also noted (Table 4-1).

The meteorological conditions of September, 1984-August, 1985 were compared to the Atmospheric Environment Canada's forecast for the monitoring period.

A record of air temperature on water and land, wind speed and direction, total precipitation and other conditions was collected. This data was useful in assessing impacts of the: freshwater influx from precipitation, wind induced current and temperature related biochemical activities (Refer to Tables 5-25 to 5-29, for each outfall area information).

4.6 Documentation of Sea Level and Tidal Activity Within the Harbour

Daily, a record of sea level gauge readings were collected by accessing the computer of the Bedford Institute of Oceanography.

TABLE 4-1 MONTHLY METEOROLOGICAL DATA FOR HALIFAX/DARTMOUTH

	1984					1985						
	<u>FALL</u>		<u>WINTER</u>			<u>SPRING</u>			<u>SUMMER</u>			
	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
MEAN TEMP. (°C)	14.0	9.2	4.6	0.2	-7.2	-4.2	-1.7	3.4	9.2	13.5	18.0	17.7
TOTAL PRECIP.(mm)												
Shearwater	53.1	58.3	38.3	138.5	80.5	92.7	103.9	84.1	103.0	341.8	137.8	138.3
Citadel	65.0	66.6	47.5	181.5	85.0	99.2	115.8	78.4	117.6	359.6	123.3	208.3
Westphal	59.5	55.7	46.6	173.3	69.2	108.5	103.4	116.7	115.5	276.0	98.7	180.2
PREVAILING WIND DIRECTION	NW	N	NW	W	W	W	W	N	N	E	S	NW
AVERAGE WIND SPEED (km/h)	13.6	14.4	16.0	17.8	20.7	17.2	19.2	15.2	12.2	13.0	9.2	8.2

Furthermore, the exact time of high and low tides were recorded by consulting Canadian Tide and Current Tables (1984-1985), published by Department of Fisheries and Ocean.

Tidal and current activities were recorded from September 1984 to August 1985 for each outfall site and are illustrated in Tables 5-25 to 5-29. Hence, tidal conditions during sampling times were determined by this data. The depth of each site was recorded in accordance to the condition of the tide. During low tide the aesthetic and water quality conditions of some outfall sites were closely monitored; to examine the extent of the effluent dispersion.

4.7 Halifax Harbour Marine Vessel Traffic

During the period of February to August 1985 inclusive the traffic of ships weighing 100-25,000 tons was recorded. Halifax Traffic Centre of Department of Transportation provided this information on a weekly basis (Table 4-2).

The vessels were catergorized on weight. Halifax Harbour contains a high volume of marine vessel activity. Marine vessels travel into the Narrows to reach the Bedford Basin Container Yard or in the docking facilities of Halifax and Dartmouth. Halifax Harbour traffic data set was collected to monitor any impact that ship movements could have on water quality, water displacement and seawater baffling. Based on compiled information, although the impact of ship baffling may not be large compared to tides and currents, the Harbour is a rather shallow body of water and the activity of marine vessels could be of importance. Effect of the displacement activity remains to be quantified. Quality and quantity of effluents discharged by the vessels were not monitored owing to the accessibilty problems and limitations of the project.

TABLE 4-2 MONTHLY HALIFAX HARBOUR TRAFFIC
FEBRUARY-SEPTEMBER 1985

(NUMBER OF TRANSITS PER MONTH)

TYPE OF MARINE VESSEL	TUNNAGE	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	ANNUAL TOTAL
<u>TOUR BOATS</u>	87	8	3	2	30	221	244	288	796
<u>HARBOR TUGS</u>	100	1,036	1,133	1,160	1,324	1,260	1,297	1,383	8,593
<u>CFMV DUTY BOATS</u>	140								
<u>SURVEY VESSELS</u>	585	18	30	18	44	79	46	105	340
<u>SUPPLY VESSELS</u>	1,590	70	47	103	75	49	55	30	429
<u>HARBOR TANKERS</u>	2,076								
<u>MARSHIPS</u>	3,000	123	211	145	235	262	225	47	1,248
<u>TANKERS</u>	9,175	6	6	0	1	4	2	194	213
<u>CONTAINER VESSELS</u>	23,250	100	452	96	119	95	105	81	1,048
<u>BULK CARRIERS</u>	25,560								
<u>MONTHLY TOTAL</u>		1,361	1,882	1,524	1,828	1,970	1,974	2,128	12,563

Section 5.0 ANALYSIS AND DISCUSSION

This section will present the results of the water quality testing conducted for sewage, sea and plume waters. Impacts of the contaminants in the Harbour waters will also be emphasized by discussing monthly and seasonal averages for the monitored water quality parameters.

Monthly and seasonal values are tabulated and presented in Appendices A, B, C, D and R. The results from the daily field and laboratory testing are recorded on computer magnetic tape and available from the Nova Scotia Department of the Environment.

The results and discussion section 5.1 is divided into two subsections of field and laboratory data and fourteen parameters. Monthly field data analysis will be discussed for 1) Temperature, 2) Dissolved Oxygen, 3) Salinity, 4) Conductance and 5) Transparency. Discussion of monthly averages of laboratory data will be presented for: 6) Chemical Oxygen Demand, 7) Biochemical Oxygen Demand, 8) Suspended Solids, 9) pH and 10) Bacterial Analysis. Seasonal averages of the same parameters will also be explained in subsection 5.2 and seasonal data for references in 5.3. In subsection 5.4 the Effects of Turbulent Processes on Halifax Harbour Contaminant Mixing, Dispersion and Removal will be discussed. Subsections 5.5 and 5.6 indicate the Visual Observations and analyze the results of a Sludge Sampling Program. Subsection 5.7 will discuss the Regression Analysis of the monthly data.

5.1 Analysis and Discussion of the Monthly Field and Laboratory Data

In subsection 5.1 a detailed analysis of the monthly averages are presented. The data is derived from compiling, averaging and analyzing the results of the fourteen wastewater quality parameters. The principal for implementation of the parameters and their relevance to Halifax Inlet system will be presented. Furthermore, the prevalent conditions in every outfall site will also be discussed.

5.1.1 Analysis and Discussion of the Monthly Field Data for Temperature

Thermal properties of the water column have a significant regulatory capacity over various physical, chemical and biological reactions. The impact of temperature on the microbial population of sewage within the plume waters is the most important regulatory process of this parameter. The treatment capacity of seawater alters with temperature changes. During plankton blooms in spring, the solar heating of the surface waters enhances photosynthesis by phytoplankton. This warm photoperiod causes rapid depletion of oxygen and nutrients. Whereas, in the winter months, the photoperiod is shortened and undesirable cold temperatures cause a slump in contaminant decomposition.

Control of chemical reactions and the existence of the density gradient are other significant functions of the water column temperature. Wind induced current, resulting from local or non-local winds cause a sharp temperature alteration during the year. These changes are more pronounced in winter and summer, when air and water temperature changes coincide. The movement of warm waters from the Harbour and their replacement with cold, and dense coastal waters is a common occurrence in the Halifax Inlet system.

Other mechanisms controlling the temperature changes within the Harbour waters are: the elevated temperatures of the sewage discharges, thermal discharges from the local industries and commercial establishments and the influx of freshwater from Sackville River. The degree of impacts and the importance of these mechanisms on the overall state of the Halifax Inlet system are significant in deciding the characteristic changes of the contaminants and inducement of the density gradient in association with salinity; which effects the rate of pollutant removal.

The coastal waters of Nova Scotia are not isothermal except from late December to April when there is uniform temperature (known as winter stagnation). These waters undergo a strong stratification during the summer months, July in particular. The shoreline along the Northwest Arm and Bedford Basin may have a small amount of ice during the winter season, but the Harbour waters remain free of ice cover.

Halifax Harbour, from the Narrows to MacNabs Island, has a mean depth of 19.3 meters, thus the surface water temperature is controlled primarily by the local weather conditions. This phenomenon appears to be more prominent during the summer months, when the local influx of freshwater enhances this condition, and the stratification facilitates the hydrodynamic override. During the winter, thermal processes indicate a movement of coastal waters in the vicinity of MacNabs Island.

Tufts Cove

Monthly field averages and the statistical analysis of the daily data are presented in Table A.1.1. of Appendix A. The respective profiles are illustrated in figures 5.01 to 5.07 A & B.

The temperature of the sewage is approximately 12-18°C; however, the expected elevated temperatures at the point of discharge were not present. This indicates an immediate cooling of the sewage at the point of discharge. The temperature of the sewage might be lower than usual since Halifax and Dartmouth sewer systems have high infiltration rates. It is not unusual for the plume waters of shallow outfall sites (i.e. Tufts Cove, Dartmouth Cove) to have similar surface water temperatures as the 150 meters stations.

There was an apparent pattern of temperature variation from month to month and from winter to summer. Generally, temperature of the Cove waters increased from winter to summer and decreased slightly from February to March as well as from July to August.

The water columns had uniform temperatures in February and this condition was comparable with the winter reference values. The March temperature values were not as uniform as February's and indicated a sharp cooling in the shallow section of the Cove. This was due to a rapid surface temperature drop induced by the climatic conditions and intrusions of cold shelf waters or a small amount of ice thawing. The Cove waters appeared to be colder than the winter temperature values of the reference sites.

During April and May a warming of the surface waters caused a slight temperature gradient in the water column. Cove water values showed horizontal

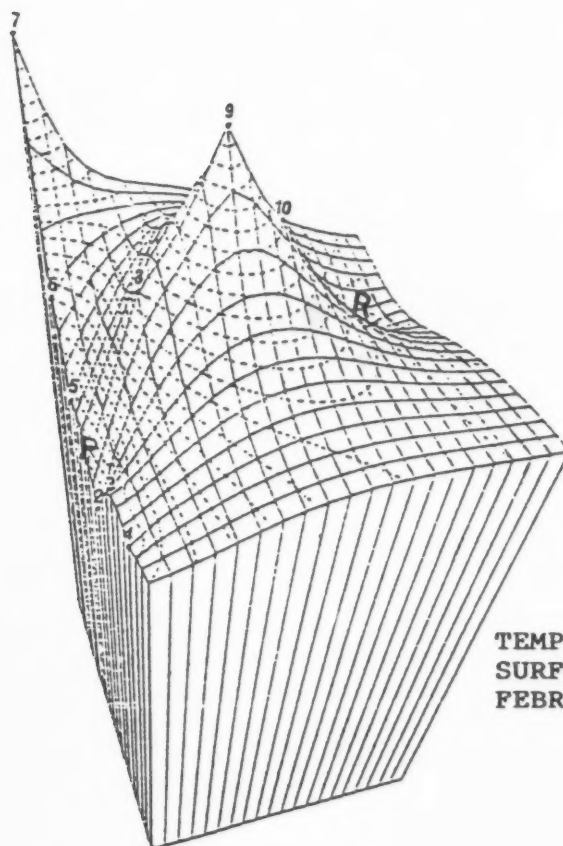


FIG: 5.01.A

TEMPERATURE VARIATION AT THE
SURFACE FOR TUFTS COVE,
FEBRUARY, 1985.

PLUME=1.8
REFERENCE=2.1

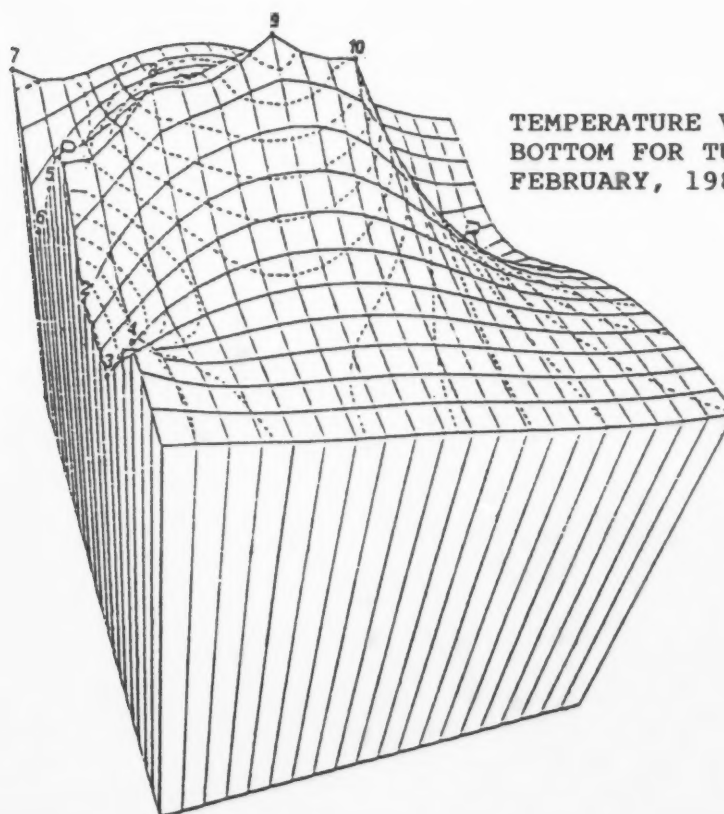


FIG: 5.01.B

TEMPERATURE VARIATION AT THE
BOTTOM FOR TUFTS COVE,
FEBRUARY, 1985.

PLUME=1.8
REFERENCE=.95

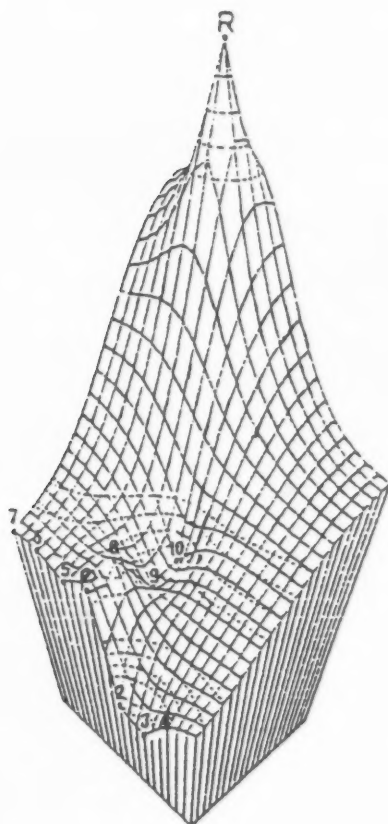


FIG:5.02.A

TEMPERATURE VARIATION AT THE
SURFACE FOR TUFTS COVE,
MARCH, 1985.

PLUME=1.9
REFERENCE=3.9

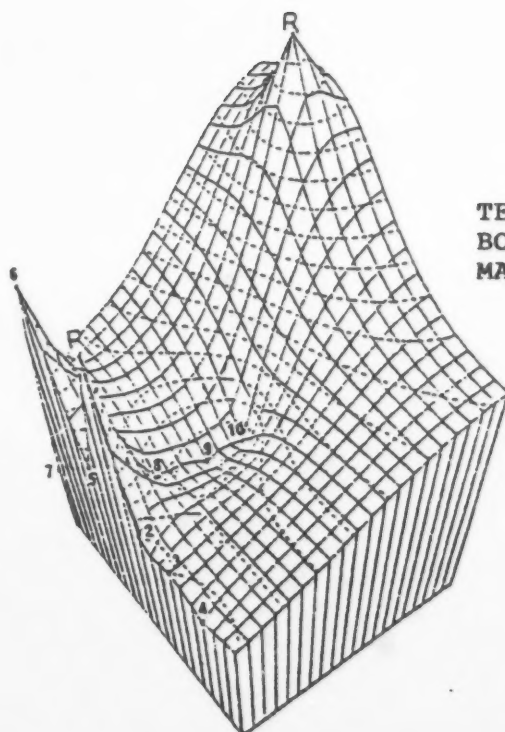


FIG:5.02.B

TEMPERATURE VARIATION AT THE
BOTTOM FOR TUFTS COVE,
MARCH, 1985.

PLUME=1.9
REFERENCE=2.6

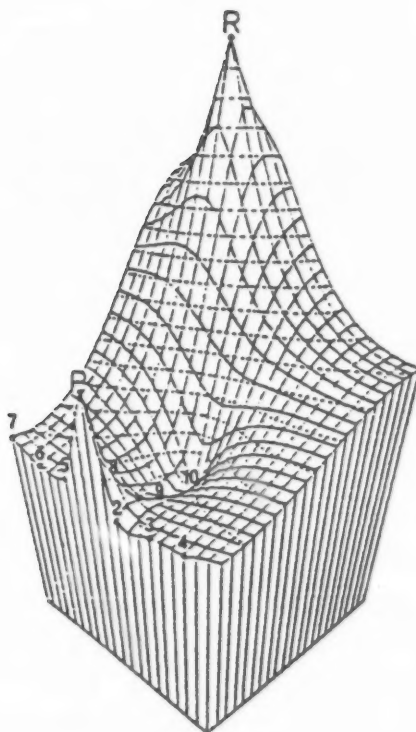


FIG: 503.A

TEMPERATURE VARIATION AT THE
SURFACE FOR TUFTS COVE,
APRIL, 1985.

PLUME=2.7
REFERENCE=3.9

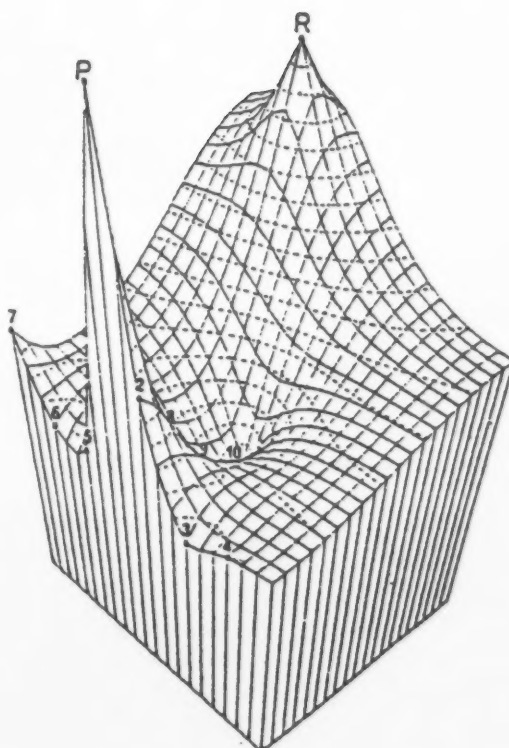


FIG: 503.B

TEMPERATURE VARIATION AT THE
BOTTOM FOR TUFTS COVE,
APRIL, 1985.

PLUME=2.7
REFERENCE=2.6

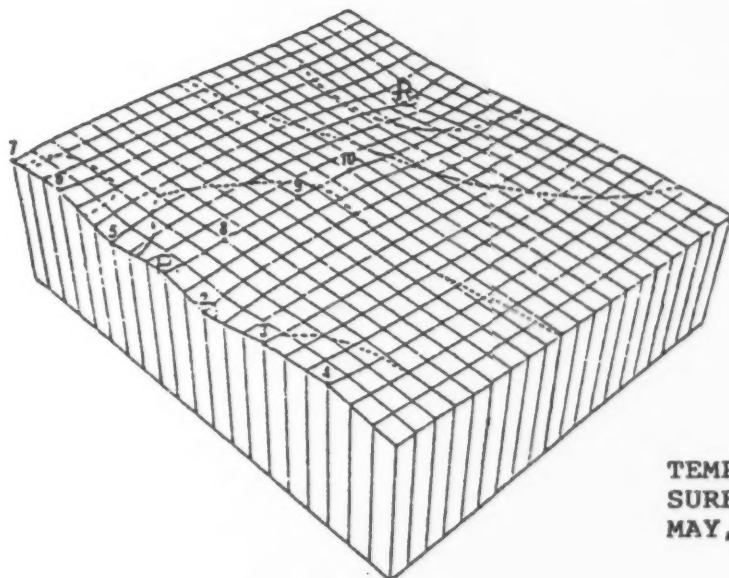


FIG: 5.04.A

TEMPERATURE VARIATION AT THE
SURFACE FOR TUFTS COVE,
MAY, 1985.

PLUME=5.8
REFERENCE=3.9

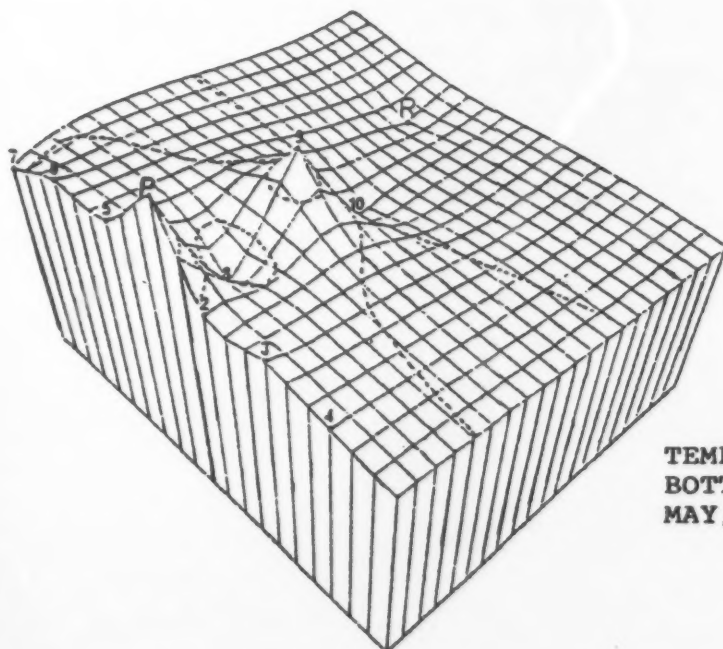


FIG: 5.04.B

TEMPERATURE VARIATION AT THE
BOTTOM FOR TUFTS COVE,
MAY, 1985.

PLUME=5.8
REFERENCE=2.6

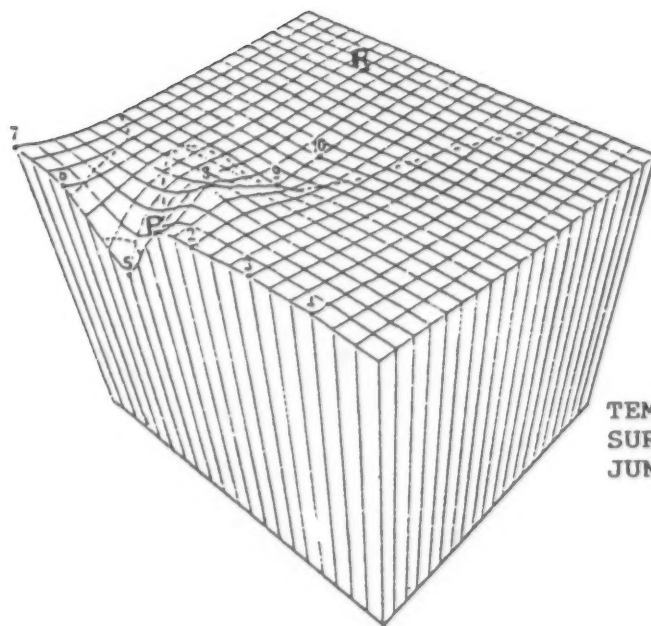


FIG: 505.A

TEMPERATURE VARIATION AT THE
SURFACE FOR TUFTS COVE,
JUNE, 1985.

PLUME=9.8
REFERENCE=9.5

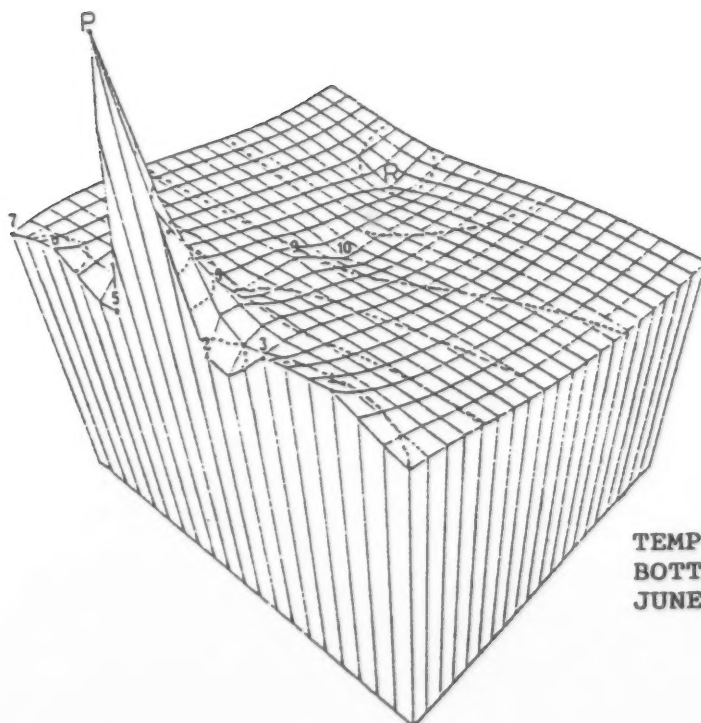


FIG: 505.B

TEMPERATURE VARIATION AT THE
BOTTOM FOR TUFTS COVE,
JUNE, 1985.

PLUME=9.8
REFERENCE=3.8

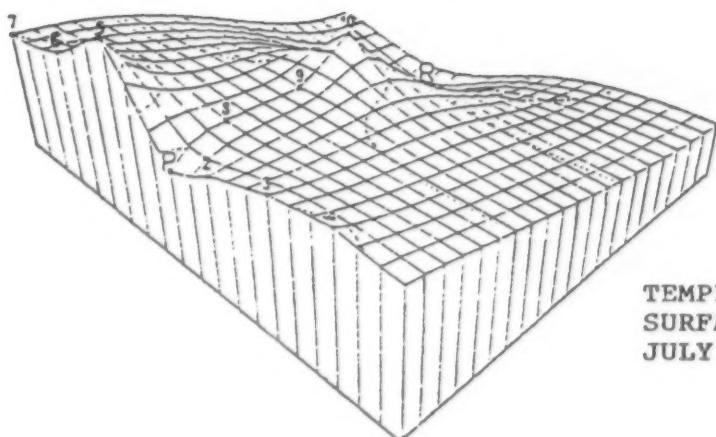


FIG: 506.A

TEMPERATURE VARIATION AT THE
SURFACE FOR TUFTS COVE,
JULY, 1985.

PLUME=13.5
REFERENCE=9.5

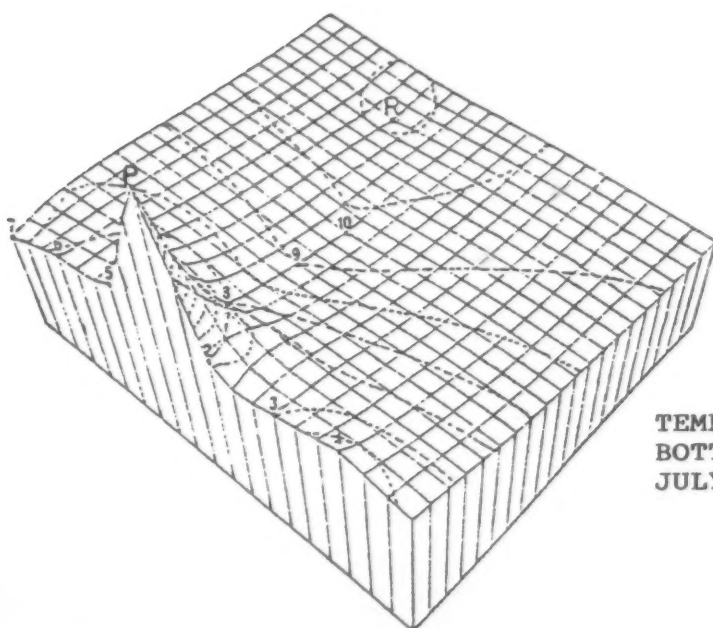


FIG: 506.B

TEMPERATURE VARIATION AT THE
BOTTOM FOR TUFTS COVE,
JULY, 1985.

PLUME=13.5
REFERENCE=3.8

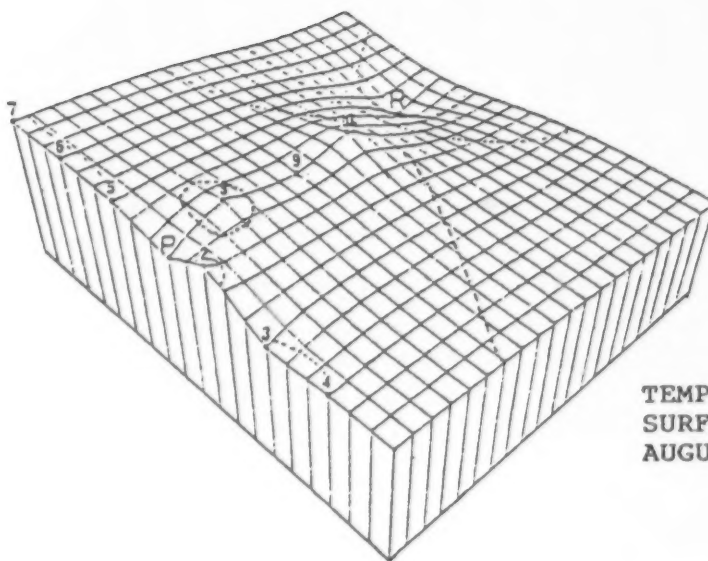


FIG: 5.07.A

TEMPERATURE VARIATION AT THE
SURFACE FOR TUFTS COVE,
AUGUST, 1985.

PLUME=11.4
REFERENCE=9.5

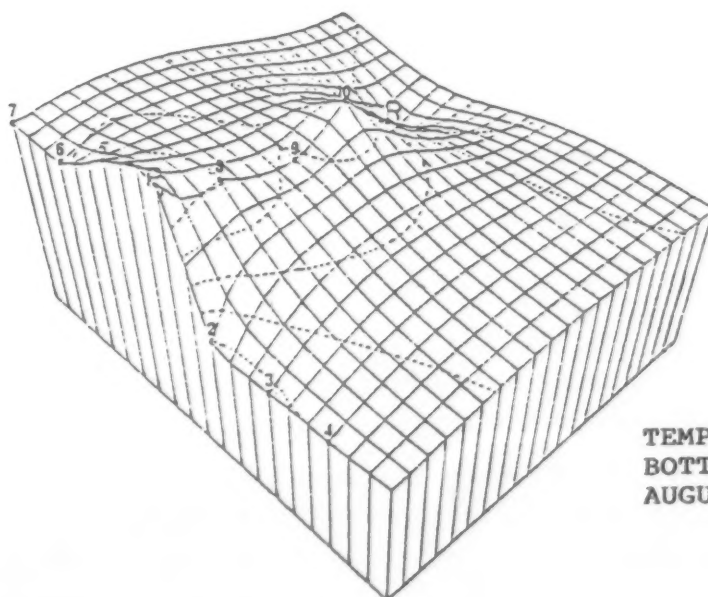


FIG: 5.07.B

TEMPERATURE VARIATION AT THE
BOTTOM FOR TUFTS COVE,
AUGUST, 1985.

PLUME=11.4
REFERENCE=3.8

and vertical mixing in stations 8, 9 and 10; movement of the Harbour waters to these stations was evident. During spring the temperatures of the reference and plume waters were not similar; exceptions to those were stations 7, 8, 9 and 10 for May.

From the beginning of June, the surface temperature increased substantially and indicated a marked thermal gradient within the water column. Even though the surface waters were 6 to 7°C warmer than the bottom waters the thermocline was not present. This condition was due to high input/removal ratio of wastewater. The water temperatures of the reference stations and outfall sites were similar for each of the respective depths. Thermal stratification of these waters was clearly delayed and very weak due to continuous sewage input and inaccessibility to Harbour waters.

The July temperature values indicated an existence of a weak thermocline at the depth of 4 meters. The temperature gradient of the reference station in the vicinity of Tufts Cove was at the depth of 9 meters. From July to August there was a temperature drop throughout the Cove; causing a deepening of the stratified layer. Temperature of the adjacent reference site indicated lower readings than those observed within the Cove for the summer months. Observed temperatures within the Cove waters, except for the point of discharge, were within 1°C of recommended ambient temperatures.

Duffus Street

Monthly averages and the relevant daily statistical analysis are presented in Table A.1.2. of Appendix A. Temperature data has been graphed in figures 5.08 to 5.14 A-C.

The temperature from the point of discharge to the 150 meter stations showed a variation of approximately 3°C and uniformly mixed water columns; this was not a significant deviation from the Harbour waters. Stations 8, 9 and 10, and to a lesser extent stations 5, 6 and 7 had warmer waters in winter, this indicated a movement of the warm plume waters towards the dry dock area. The temperature of the Harbour waters was relatively warmer than the plume waters at stations 2, 3 and 4. This indicated a movement of the colder coastal waters landward.

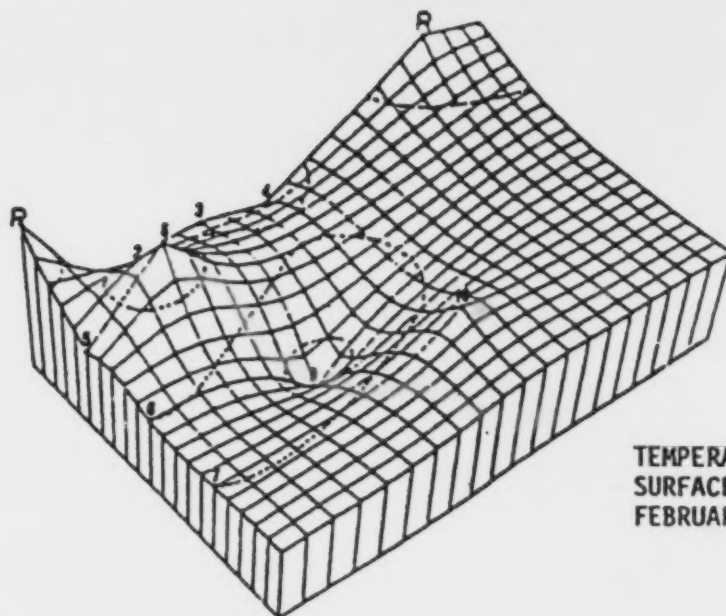


FIG: 5.08.A

TEMPERATURE VARIATION AT THE
SURFACE FOR DUFFUS STREET,
FEBRUARY, 1985.

PLUME=2.0
REFERENCE=2.1

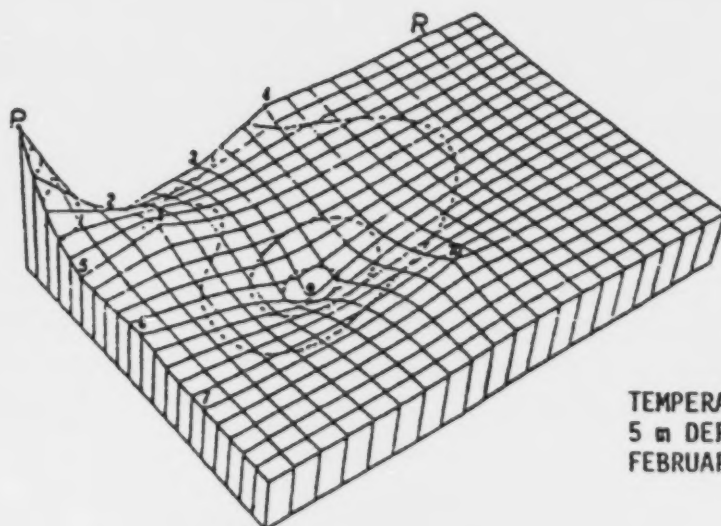


FIG: 5.08.B

TEMPERATURE VARIATION AT THE
5 m DEPTH FOR DUFFUS STREET,
FEBRUARY, 1985.

PLUME=2.0
REFERENCE=0.9

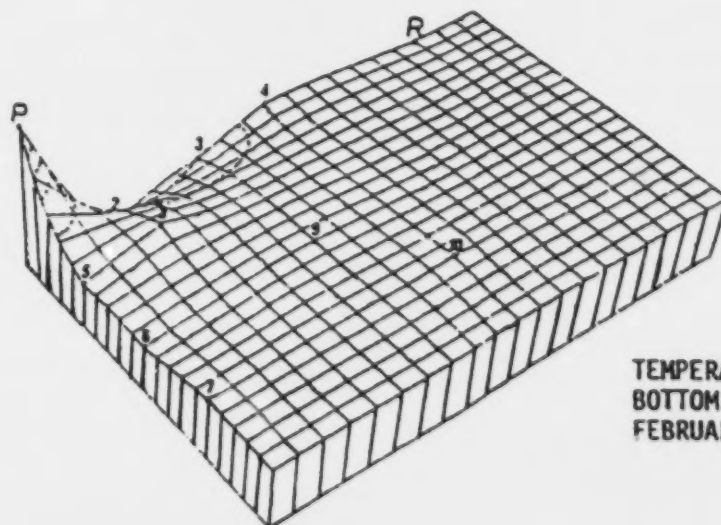


FIG: 5.08.C

TEMPERATURE VARIATION AT THE
BOTTOM FOR DUFFUS STREET,
FEBRUARY, 1985.

PLUME=2.0
REFERENCE=0.7

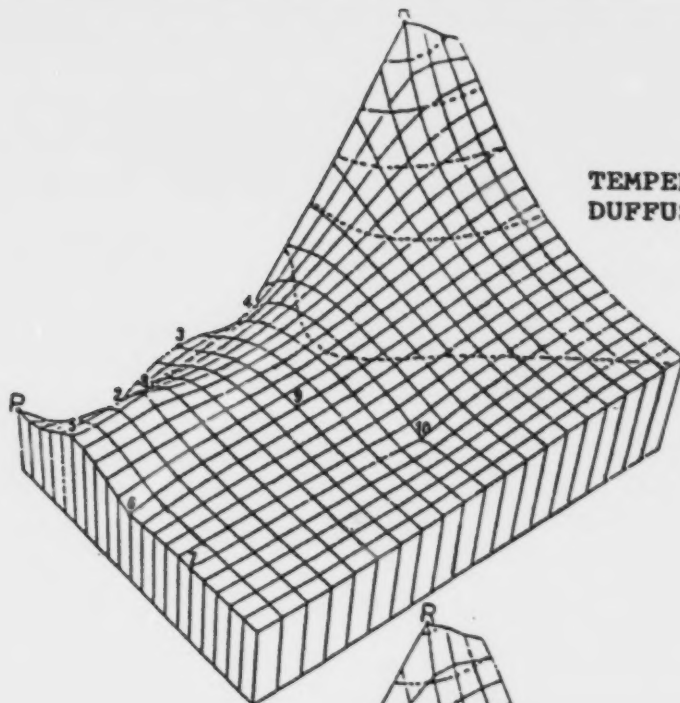


FIG: 5.09.A

TEMPERATURE VARIATION FOR
DUFFUS STREET, MARCH, 1985.

PLUME=1.0
REFERENCE=3.8

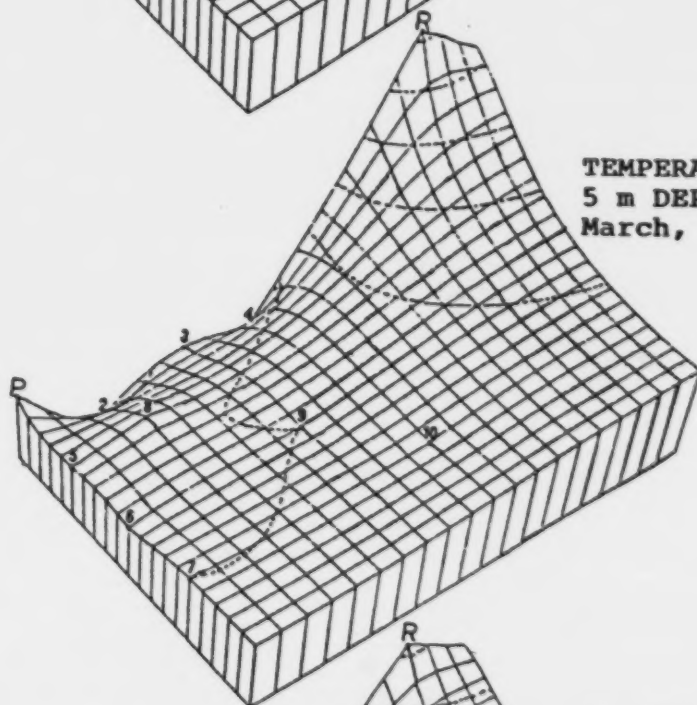


FIG: 5.09.B

TEMPERATURE VARIATION AT THE
5 m DEPTH FOR DUFFUS STREET,
March, 1985.

PLUME=1.0
REFERENCE=3.3

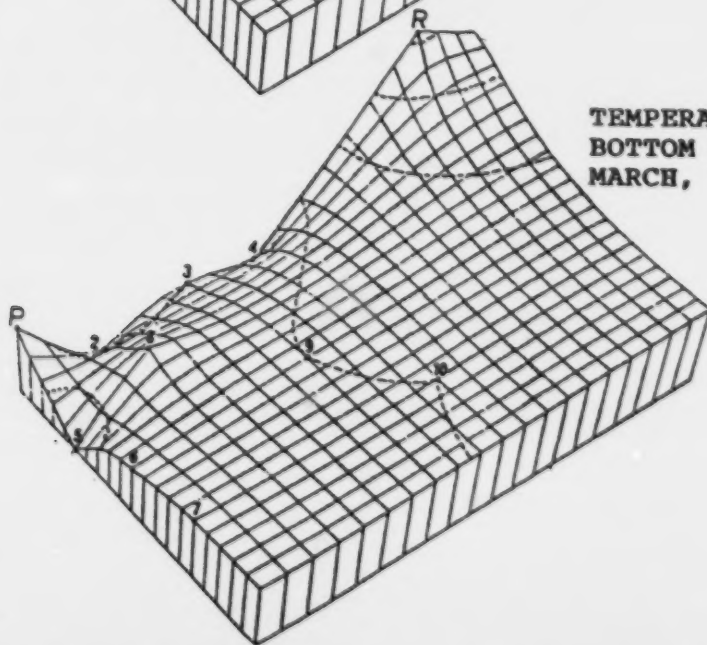


FIG: 5.09.C

TEMPERATURE VARIATION AT THE
BOTTOM FOR DUFFUS STREET,
MARCH, 1985.

PLUME=1.0
REFERENCE=2.0

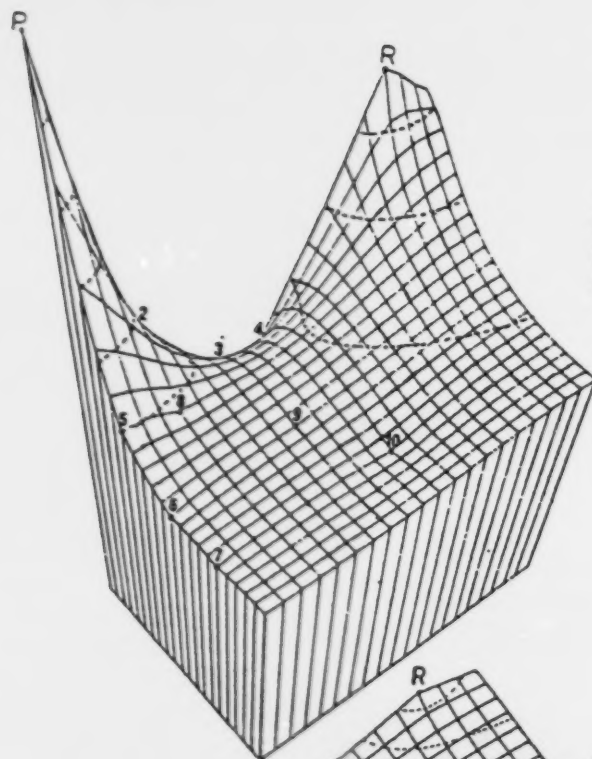


FIG: 5.10.A

TEMPERATURE VARIATION AT THE
SURFACE FOR DUFFUS STREET,
APRIL, 1985.

PLUME=5.0
REFERENCE=3.8

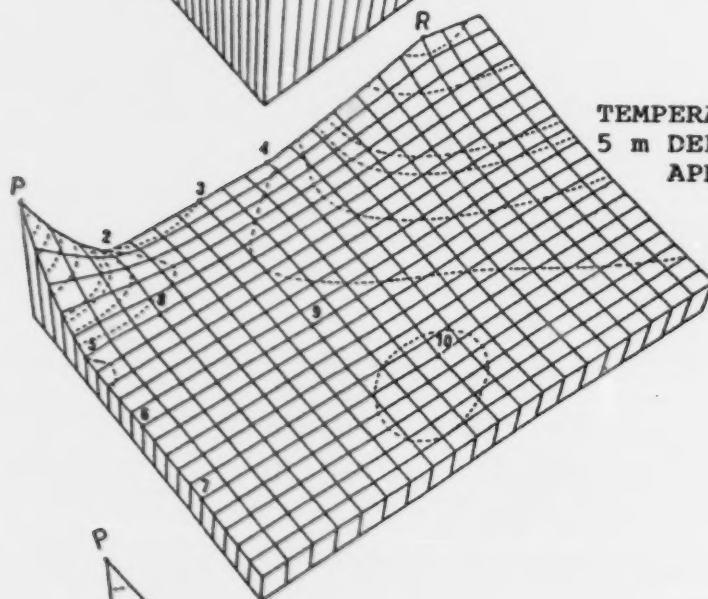


FIG: 5.10.B

TEMPERATURE VARIATION FOR THE
5 m DEPTH, DUFFUS STREET,
APRIL, 1985.

PLUME=5.0
REFERENCE=3.3

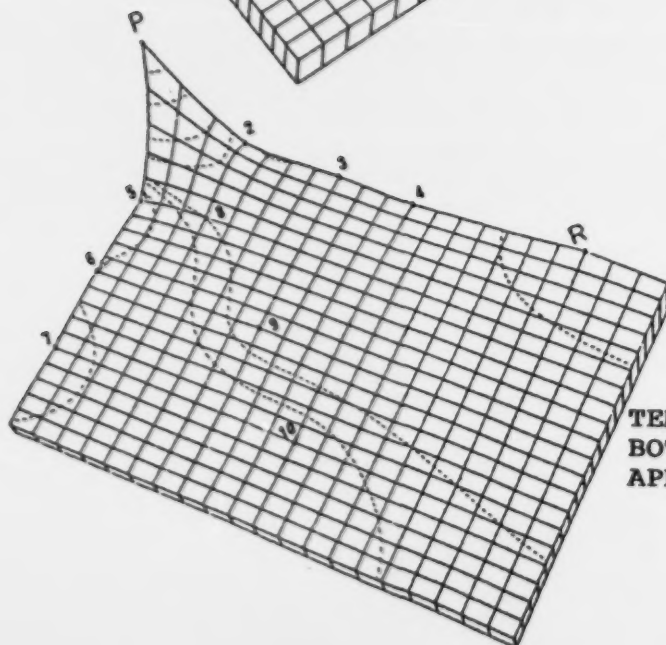


FIG: 5.10.C

TEMPERATURE VARIATION AT THE
BOTTOM FOR DUFFUS STREET,
APRIL, 1985.

PLUME=5.0
REFERENCE=2.0

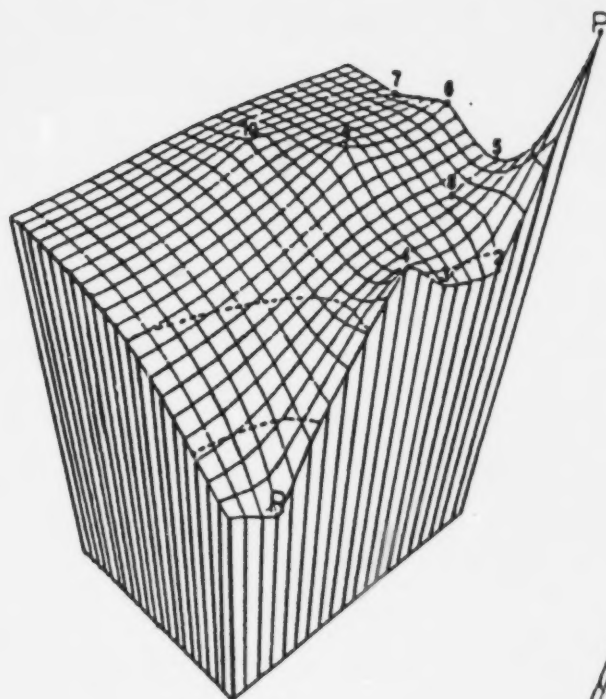


FIG: 5.11.A

TEMPERATURE VARIATION AT THE
SURFACE FOR DUFFUS STREET,
MAY, 1985.

PLUME=6.2
REFERENCE=3.8

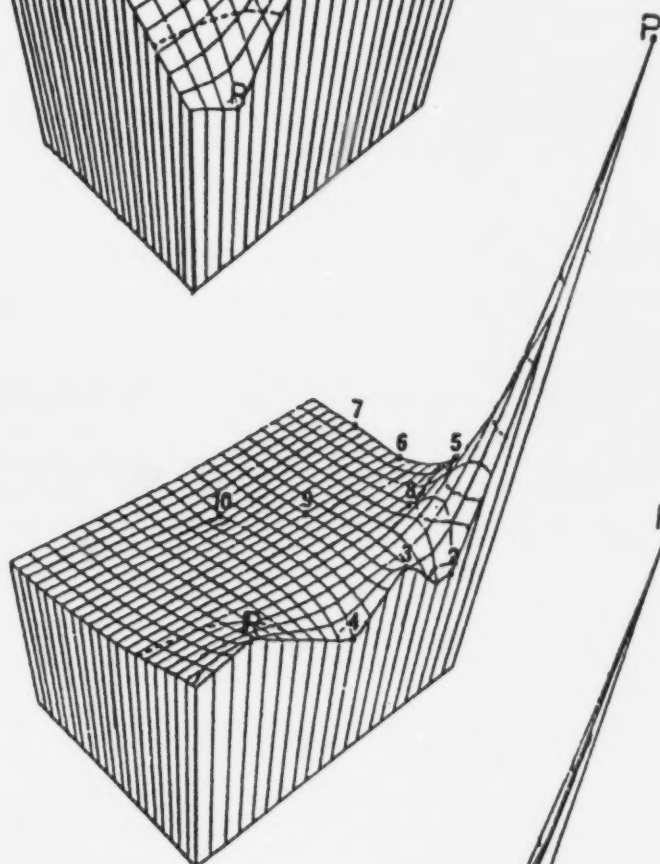


FIG: 5.11.B

TEMPERATURE VARIATION AT THE
5 m DEPTH FOR DUFFUS STREET,
MAY, 1985.

PLUME=6.2
REFERENCE=3.3

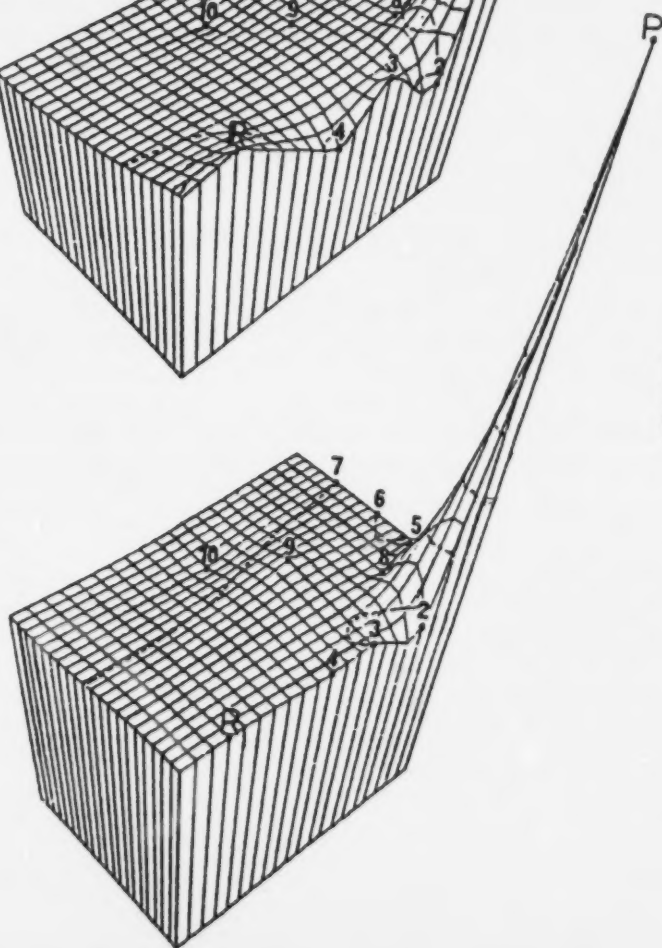


FIG: 5.11.C

TEMPERATURE VARIATION AT THE
BOTTOM FOR DUFFUS STREET,
MAY, 1985.

PLUME=6.2
REFERENCE=2.0

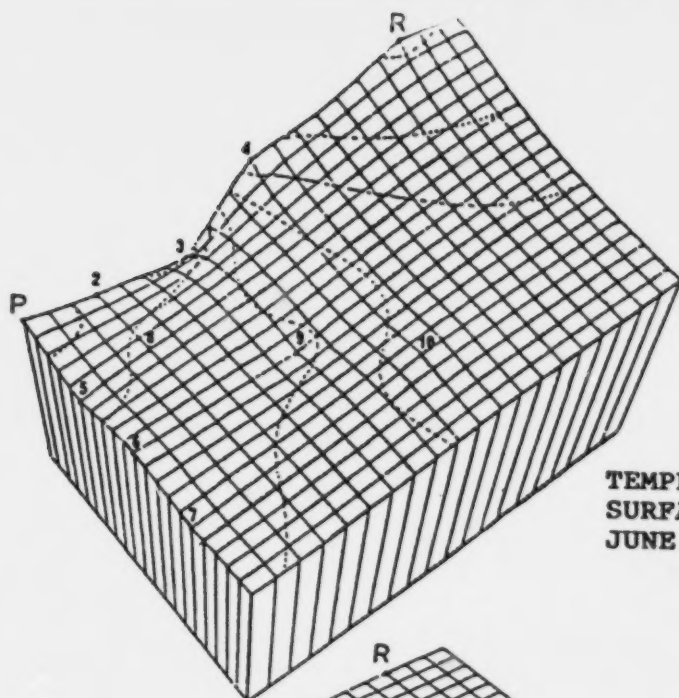


FIG: 512.A

TEMPERATURE VARIATION AT THE
SURFACE FOR DUFFUS STREET,
JUNE, 1985.

PLUME=7.5
REFERENCE=10.3

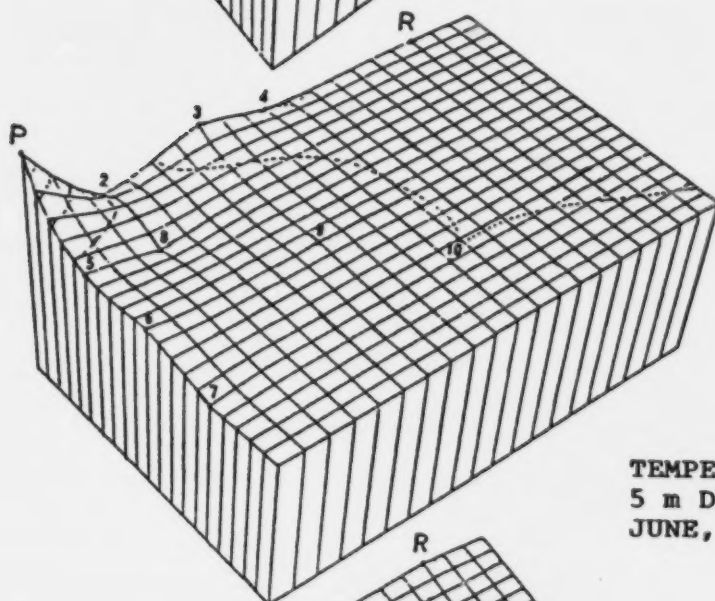


FIG: 512.B

TEMPERATURE VARIATION AT THE
5 m DEPTH FOR DUFFUS STREET,
JUNE, 1985.

PLUME=7.5
REFERENCE=5.6

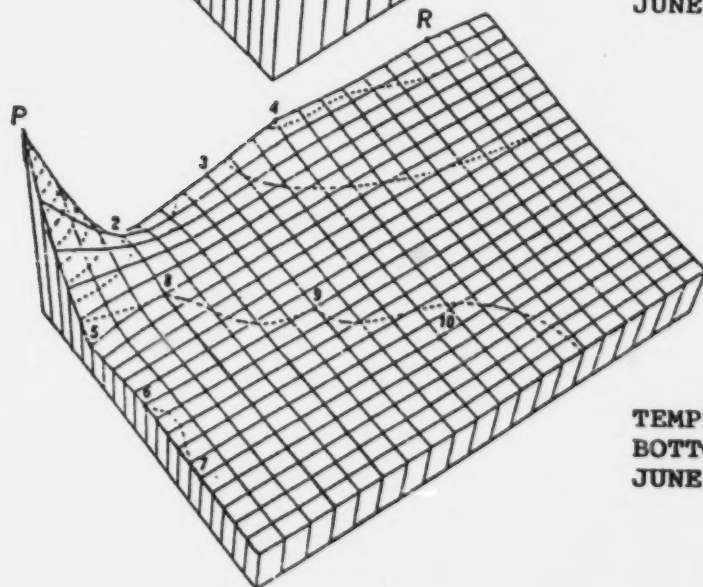


FIG: 512.C

TEMPERATURE VARIATION AT THE
BOTTOM FOR DUFFUS STREET,
JUNE, 1985.

PLUME=7.5
REFERENCE=3.3

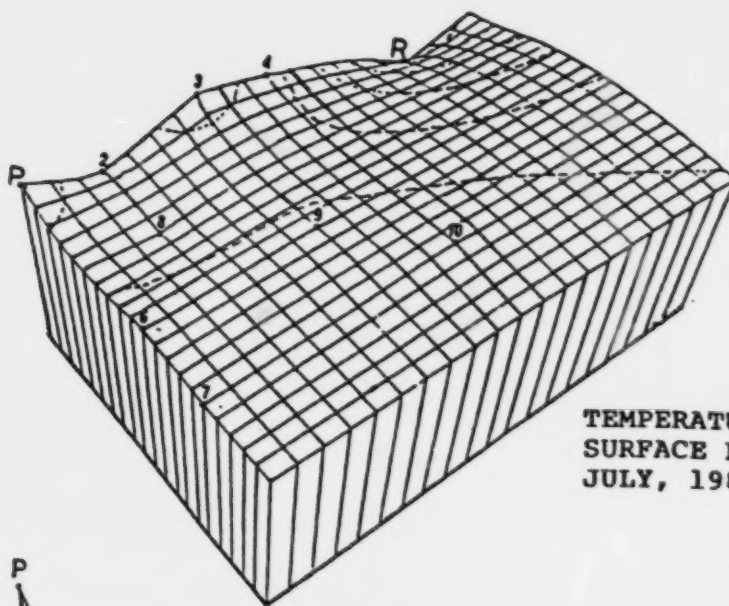


FIG: 5.13.A

TEMPERATURE VARIATION AT THE
SURFACE FOR DUFFUS STREET,
JULY, 1985.

PLUME=13.1
REFERENCE=10.3

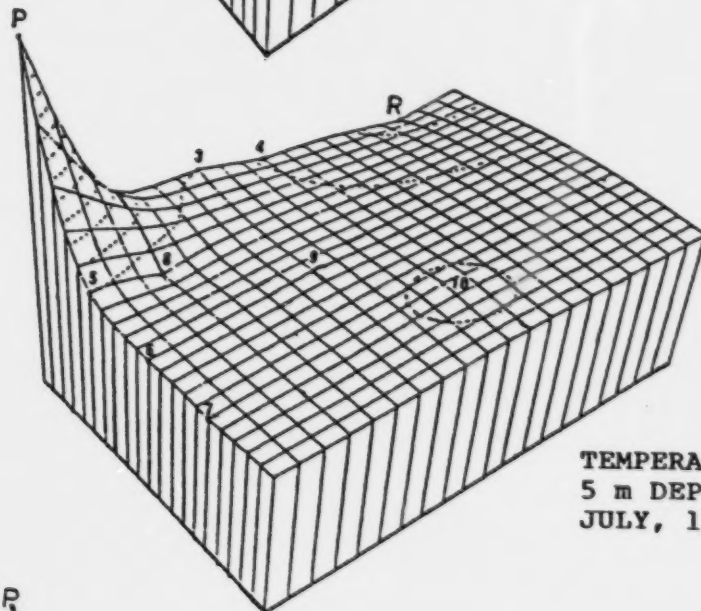


FIG: 5.13.B

TEMPERATURE VARIATION FOR THE
5 m DEPTH FOR DUFFUS STREET,
JULY, 1985.

PLUME=13.1
REFERENCE=5.6

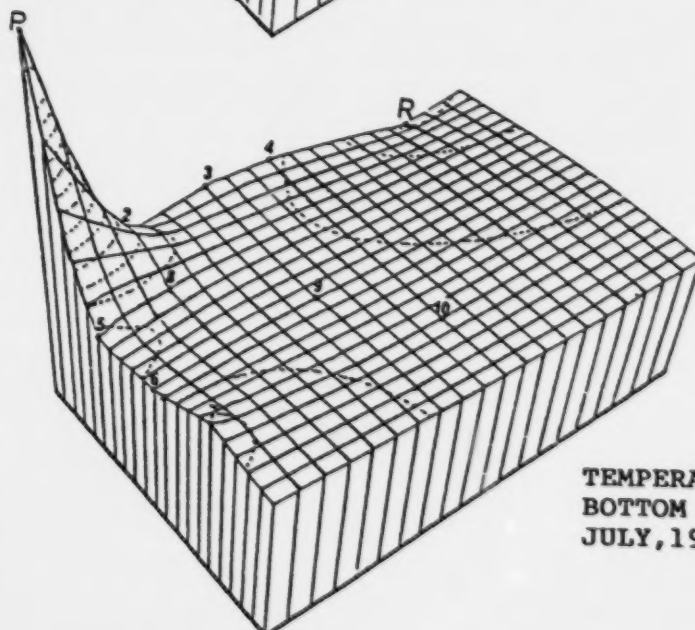


FIG: 5.13.C

TEMPERATURE VARIATION AT THE
BOTTOM FOR DUFFUS STREET,
JULY, 1985.

PLUME=13.1
REFERENCE=3.3

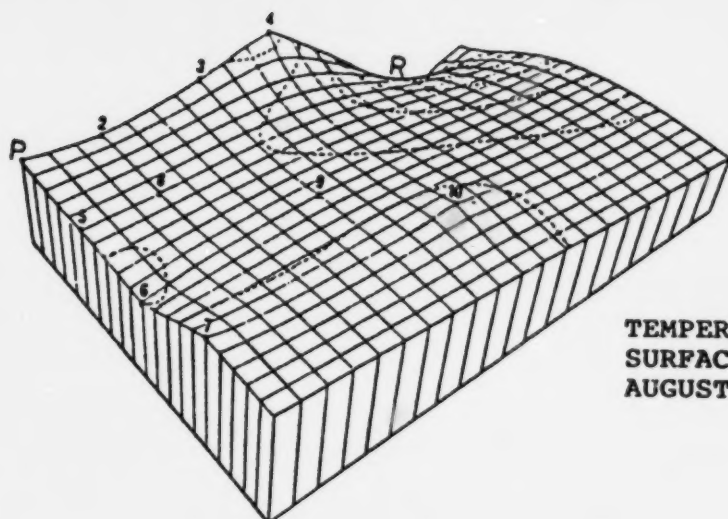


FIG: 5M.A

TEMPERATURE VARIATION AT THE
SURFACE FOR DUFFUS STREET,
AUGUST, 1985.

PLUME=13.9
REFERENCE=10.3

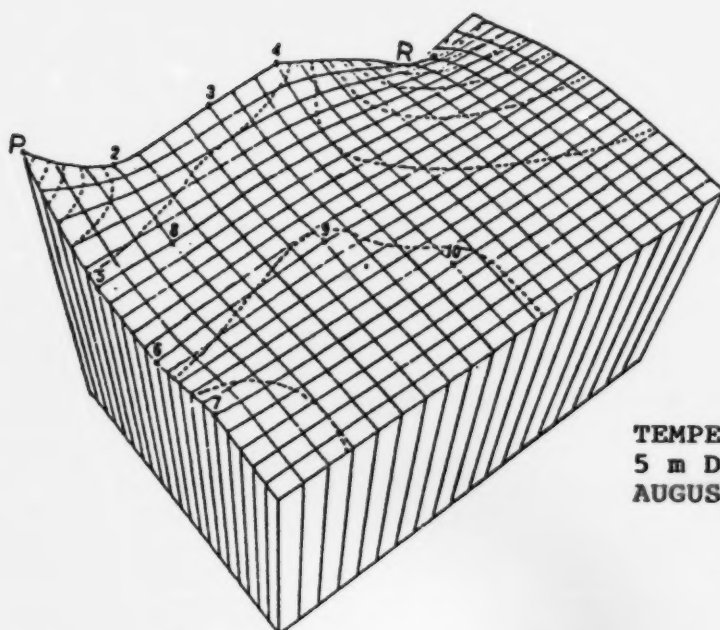


FIG: 5M.B

TEMPERATURE VARIATION AT THE
5 m DEPTH FOR DUFFUS STREET,
AUGUST, 1985.

PLUME=13.9
REFERENCE=5.6

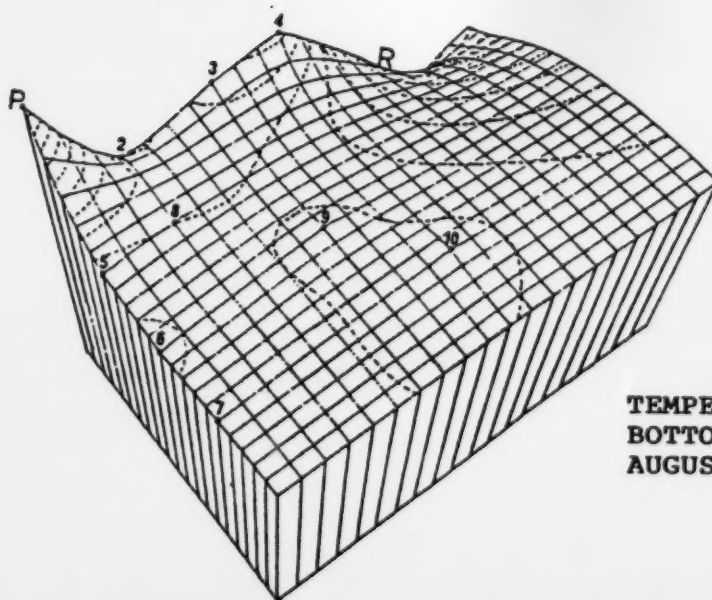


FIG: 5M.C

TEMPERATURE VARIATION AT THE
BOTTOM FOR DUFFUS STREET,
AUGUST, 1985.

PLUME=13.9
REFERENCE=3.3

As in Tufts Cove, temperature of the plume waters decreased from February to March. General direction of the plume water movement was southeasterly. There was an increase in temperature of the effluents during April, but the general character of the plume waters remained unchanged. Spring temperatures of the plume waters, except for May, were lower than the Harbour waters but thermal variation within the plume's water column was similar.

A 2°C temperature variation in the water column, as well as general warming of the plume waters, was characteristic of May. A hydrodynamic override of freshwater sewage on seawater was present throughout the plume area, otherwise the water column had the same temperatures as the reference stations.

An average thermal variation of 4 to 6°C between the surface and bottom of the water column was observed during June and July. The stratified layer in Duffus Street outfall waters was shallower (2-3 meters) than Tufts Cove, and similar to the reference site, indicating a high removal to input ratio. During both June and July hydrodynamic overriding of warmer freshwater sewage caused an accumulation near Halifax Industries. During July, there was an occasion of a cold water intrusion into this outfall area when the bottom temperatures dropped below 5°C. The summer reference values were similar to the station values of June and July. The plume waters indicated a warming of surface waters due to climatic conditions in August, this was indicated by the increase in temperatures in the water column and this process continued with every sampling period. The depth of the stratified layer in August increased to approximately 7 meters.

Dartmouth Cove

Monthly field averages of temperature and the relevant daily statistical analysis are presented in Table A.1.3. of Appendix A.

The winter values of temperature were uniform throughout the water column showing vertically and horizontally mixed plume waters. Stations 8, 9 and 10 had similar temperatures to those of the reference stations, while the remaining stations were lower.

Irregular horizontal and vertical thermal variation in April was unusual, but a combination of the spring thaw, a large amount of runoff and Harbour water intrusion could be the reason for this irregularity. During this month as well as May and June a hydrodynamic override of freshwater sewage was present, and an accumulation of wastewater around station 6 was evident.

During the late spring and early summer the continuous warming of the surface waters resulted in a very low thermal gradient of 3-5°C at a depth of 1 to 2 meters; this was shallower than observed in other outfall sites and resemble an override indicating the impact of a low removal rate on stratification. The temperature values of the surface waters of Dartmouth Cove, for the month of May, were substantially higher than the reference stations.

The formation of a thermocline was not clearly evident, but thermal variation of the water column was present earlier than in the other outfall sites. During July and August, temperatures of the respective depths within the Cove and the reference stations were similar.

Sackville Street

Monthly field averages of temperature and the statistical analysis of the daily data are presented in Table A.1.4 of Appendix A.

A uniform temperature within the water column and well mixed plume waters were present during February and March. Overall temperature of these waters were lower than the other outfall sites during the winter and spring. The temperature of the reference sites was within the same range as the plume waters during the winter and warmer in spring.

The April temperature values of the plume waters were lower than the references, but higher than March's, this showed a gradual warming of surface waters. The increase in temperature both on surface and bottom, to a variable level, was observed from April to August.

A very weak stratification began in late May and continued till August. The thermocline of Sackville Street plume waters was not very evident since the greatest thermal jump in the summer was 1.5°C , this was much smaller than observed for the comparable site Duffus Street. The large volume and high velocity of the jet of sewage into this area might be the cause for the existence of weakly stratified waters. The reference stations in the vicinity of the outfall had 3°C temperature variation and a stratified layer 7 meters deep. Summer reference temperature values were within the same range as the June values of the plume waters.

Pier "A"

Monthly field averages of temperature and the relevant statistical analysis of daily data are presented in Table A.1.5. of Appendix A.

February and March temperature values for the Pier were higher than that of the other outfall sites, but as well mixed as the other plume waters. The plume waters had similar temperatures as those of the reference stations in winter, but not in spring. Slightly warmer surface temperatures had been observed in February and March.

March and April temperature indicated a slight warming of the surface waters. During both months the plume waters and references were different. In March there was an intrusion of cold waters which caused a removal of warmer waters from the bottom of the Pier. This condition could be due to the spring thaw also.

The thermocline of Pier "A" was formed in July at the depth of 2-3 meters, this was shallower than the reference sites (7 meters). Prior to the formation of a thermocline a continuous warming of surface and bottom waters was evident. During June the pattern of horizontal and vertical thermal variation was highly irregular indicating a possible low level of on-site mixing or irregular Harbour water movement to the area. In every case, except for August, the reference temperatures were closely correlated with those of Pier "A".

Summary

It is conclusive that the temperature of the Harbour waters is mainly controlled by the local climatic conditions as well as local and offshore water circulation mechanisms. Horizontal thermal variations were mostly correlated with the hydrodynamic override of freshwater sewage on seawater. The immediate cooling or mixing of the sewage within the first 50 meters of the point of discharge and a low temperature of sewage due to the high volume of infiltration were also factors. On two occasions a distinct intrusion of cold saline waters was observed in the surface and bottom of the plume waters. The spring thaw effectively changed the thermal behaviour of the outfall sites. The vertical temperature variations generally showed a marked warming of the surface waters from April to July and eventually a thermocline formed in the waters of every outfall site. The depth of the stratified layer, temperature variation causing the formation of a thermocline, and the period of stratification was variable for every outfall site as well as the reference stations in the vicinity of these sites.

The temperature data indicated a certain amount of containment or pooling of the sewage in every site. During February and March, when the water column was well mixed, the accumulation of the sewage was most evident. Even though Sackville Street is relatively accessible to the general water circulation of the Harbour, the velocity and volume of the sewage emanating from this outfall pipe was interfering with stratification of the waters within 150 meters of plume area.

The temperature of the plume waters differed ± 2 to 5°C than that of reference stations within the Harbour and ± 1 to 10°C from the temperatures of the reference site outside the Harbour. These differences were substantially higher than the recommended $\pm 1^{\circ}\text{C}$ ambient temperature variation for receiving waters. However, the detrimental effects of low temperature on bacteria clumping and slowing the rate of organic decomposition is more significant in the plume waters. The immediate cooling of sewage at the point of discharge eliminated the problem of thermal pollution, but most probably the impact of thermal effluent from the industries was greater than those observed at the outfall sites. The most significant impact of sewage is its effect on the primary biological activities due to interference with normal stratification of these waters.

5.1.2 Analysis and Discussion of the Monthly Field Data for Dissolved Oxygen

The dependency of living organisms upon the presence of "free oxygen" is a known fact, with consideration that life sustains from the production of energy, resulting from a series of oxidation-reduction reactions, utilizing a great amount of oxygen. This condition is of special interest when dealing with fresh or marine waters, since oxygen has low solubility rate in water. The limitations exerted by temperature, partial pressure, salinity and contaminants as well as the vital necessity of oxygen levels in maintaining living organisms indicates the significance of controlling this parameter in contaminated, cold, saline waters.

The solubility of atmospheric oxygen in freshwater ranges from 7.0 to 14.6 mg/L at 30°C to 0°C, respectively. Variable seasonal atmospheric pressure, air and water temperature changes as well as the density gradient of the estuarine waters, controls the level of available oxygen. The source-strength of contaminants, origin of biochemical pollutants and various activities of marine microorganisms decide the character and rate of oxygen depletion.

Daily changes in dissolved oxygen concentrations result from compounded effects of respiration, contaminant oxidation and photosynthesis (light stage of photosynthesis), of periphyton and phytoplankton. Furthermore, physical restrictions such as depth of the site, water turbulence, surface drainage, turbidity and waste-loadings also cause daily fluctuations of dissolved oxygen in the water columns of the plume and reference waters.

Physical oceanography phenomena such as cold water intrusions, vertical mixing of the water columns, presence of a pycnocline, seasonal and climatical conditions caused variable levels of depletion and reoxygenation in the outfall areas. In the case of the study area, dissolved oxygen in the surface of the plume waters were effected by the hydrodynamic movement of sewage on seawater. The bottom waters had variable oxygen depletion levels depending upon the DO uptake by the sludge and the decomposition rate of the sewage contaminants for each specific site.

During the spring and summer as a result of: a) high contaminant loading resulting from spring thaw and storm runoff, b) elevated levels of biochemical activities resulted from the warming of Harbour waters, c) an increase in degradation of the contaminants and plankton blooms there was a higher level of oxygen depletion. For these reasons, during the summer months, the critical limits are at 6.0 to 8.0 mg/L of dissolved oxygen; since oxygen is less soluble in warm waters and elevated biochemical activities might deplete the available oxygen to the critical limits. The standard limits of dissolved oxygen are set at greater than 5.0 mg/L for fishing and bathing. The limited use zone (plume area) needed for the oxygen demand content of sewage to return to desirable seawater BOD levels is a body of water 3-10 km long with a depth of 20 meters. However, in Halifax Harbour the tidal and current activities effect the waters within the outfalls sites differently.

Tufts Cove

Monthly field averages and statistical analysis of the daily data are presented in Table A.2.1 of Appendix A. The graphical presentation of the data are illustrated in figures 5.15 to 5.21 A & B.

The initial dissolved oxygen at the point of discharge was in the range of 7.1 to 12.7 mg/L which was high and indicated that the sewage contained an elevated DO before being discharged. A lower DO throughout the plume waters emphasized this observation. During February there was a sharp decrease of available oxygen at station 10, indicating a rapid deoxygenation of the Cove waters. A strong override of sewage on the upper 2-3 meters was evident. The surface stations had lower dissolved oxygen levels than the bottom stations (an elevated DO was expected at low temperatures), indicating the independence of dissolved oxygen from that of temperature. The oxygen levels of the reference sites increased from the surface to the bottom of the water column, and in every instance these values were 1.0 to 5.0 mg/L higher than those observed for the Cove waters. Therefore, the containment of sewage in the Cove caused a great DO depletion.

During the spring months general pooling of the contaminants at stations 2, 3 and 4 was evident. Stations 9 and 10 indicated mixing with Harbour waters. There was a dissolved oxygen recovery present from winter to March

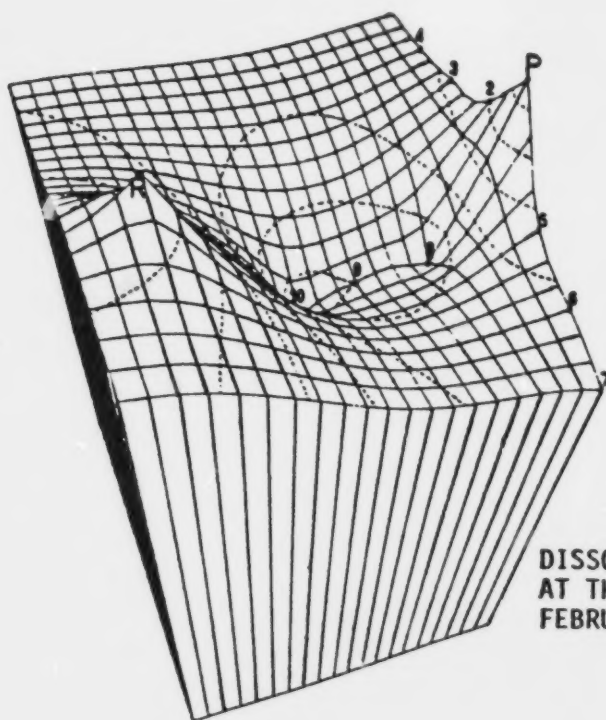


FIG: 5.15.A

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE SURFACE, FOR TUFTS COVE FOR
FEBRUARY, 1985.

PLUME=9.8
REFERENCE=10.6

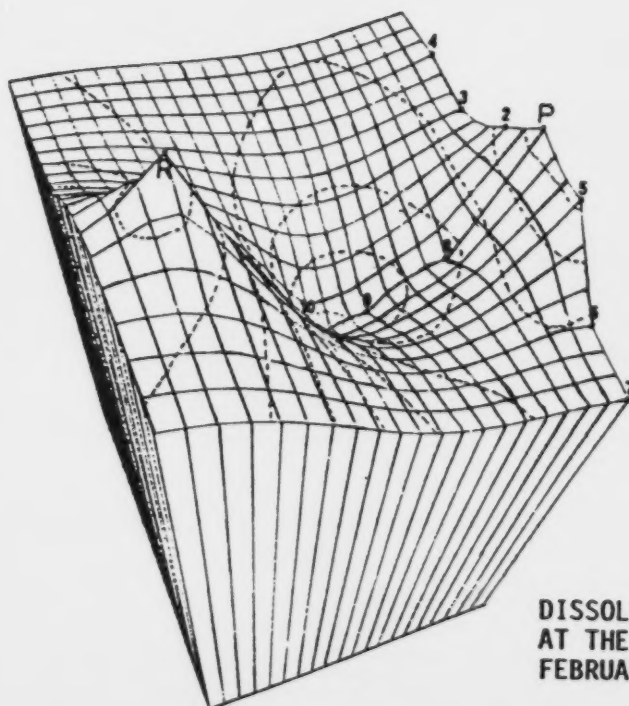


FIG: 5.15.B

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE BOTTOM, TUFTS COVE FOR
FEBRUARY, 1985.

PLUME=9.8
REFERENCE=14.4

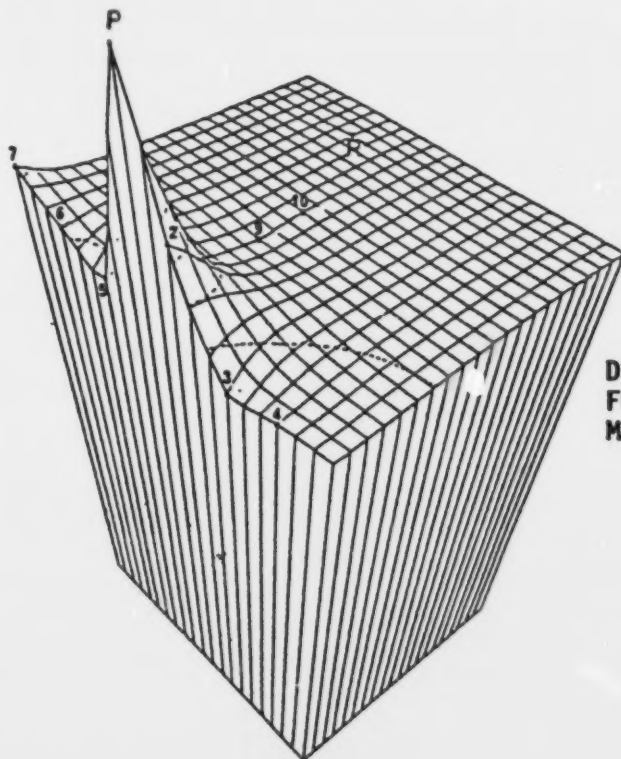


FIG: 5.16.A

DISSOLVED OXYGEN DISTRIBUTION PATTERN
FOR THE SURFACE, TUFTS COVE FOR
MARCH, 1985.

PLUME=12.7
REFERENCE=9.8

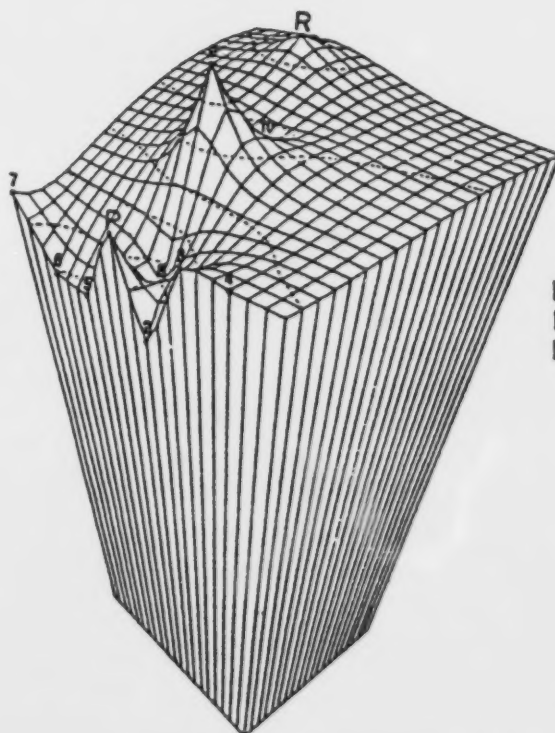


FIG: 5.16.B

DISSOLVED OXYGEN DISTRIBUTION PATTERN
FOR THE BOTTOM, TUFTS COVE FOR
MARCH, 1985.

PLUME=12.7
REFERENCE=10.6

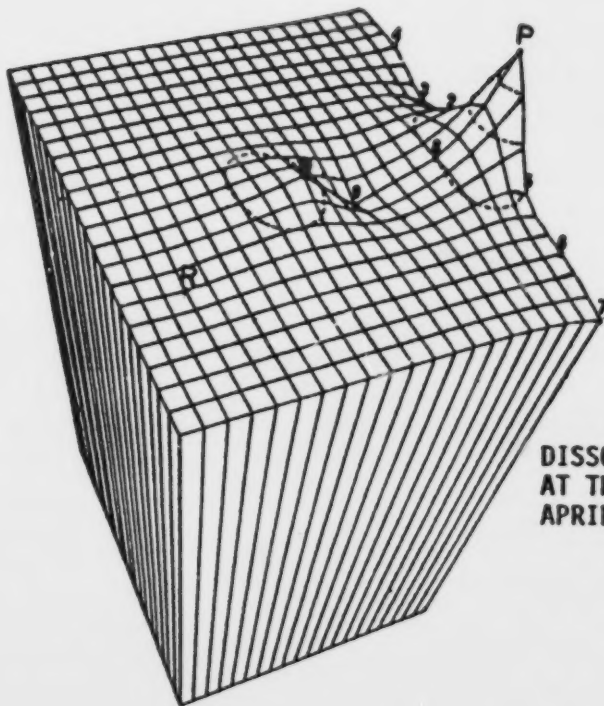


FIG: 5.17.A

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE SURFACE, TUFTS COVE FOR
APRIL, 1985.

PLUME=11.4
REFERENCE=9.8

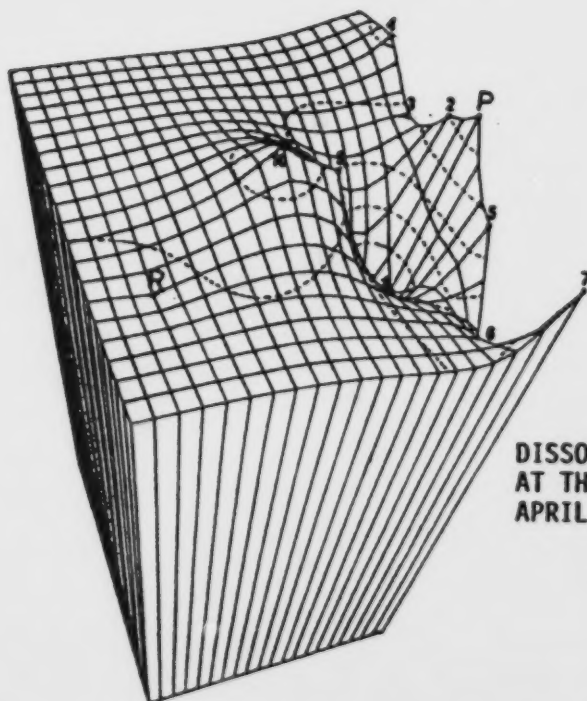


FIG: 5.17.B

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE BOTTOM, TUFTS COVE FOR
APRIL, 1985.

PLUME=11.4
REFERENCE=10.6

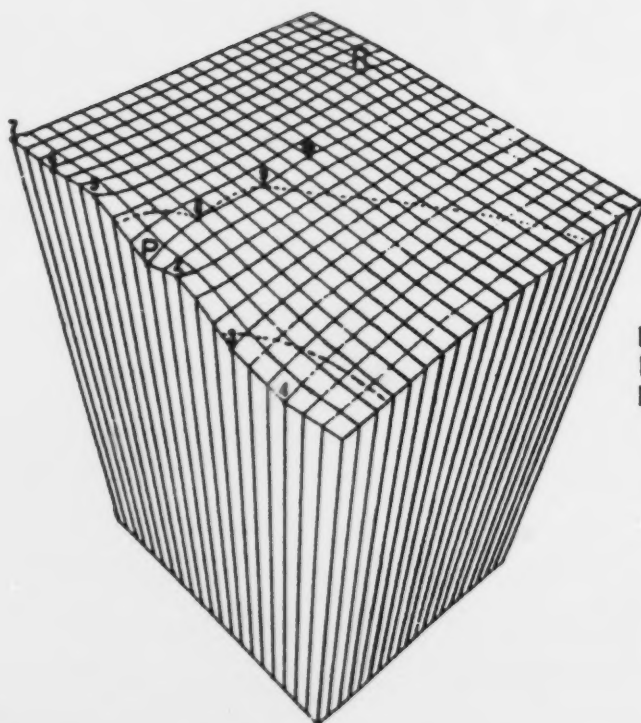


FIG: 5.18.A

DISSOLVED OXYGEN DISTRIBUTION PATTERN
FOR THE SURFACE, TUFTS COVE FOR
MAY, 1985.

PLUME=9.2
REFERENCE=9.8

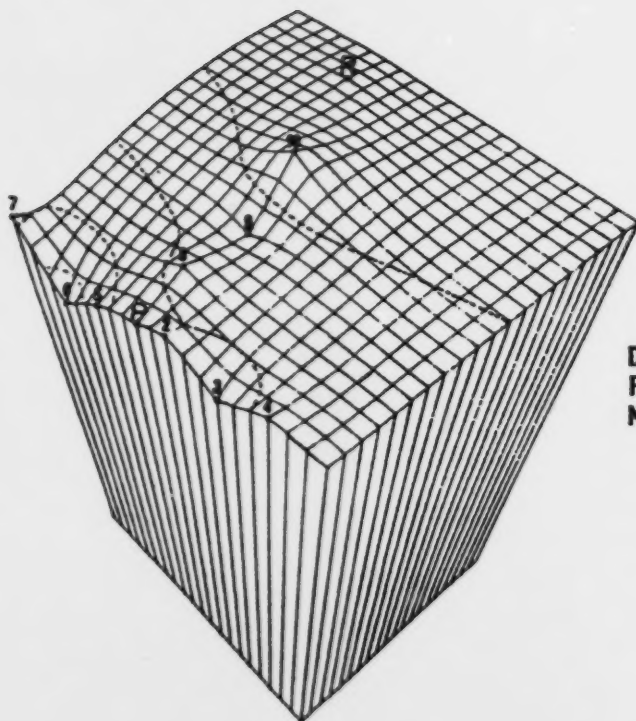


FIG: 5.18.B

DISSOLVED OXYGEN DISTRIBUTION PATTERN
FOR THE BOTTOM, TUFTS COVE FOR
MAY, 1985.

PLUME=9.2
REFERENCE=10.6

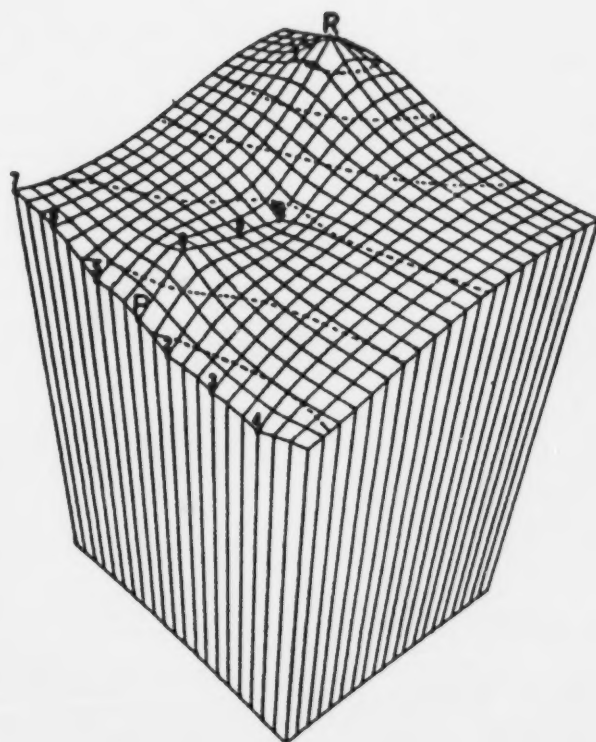


FIG : 5.19.A

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE SURFACE, TUFTS COVE FOR
JUNE, 1985.

PLUME=7.1
REFERENCE=10.0

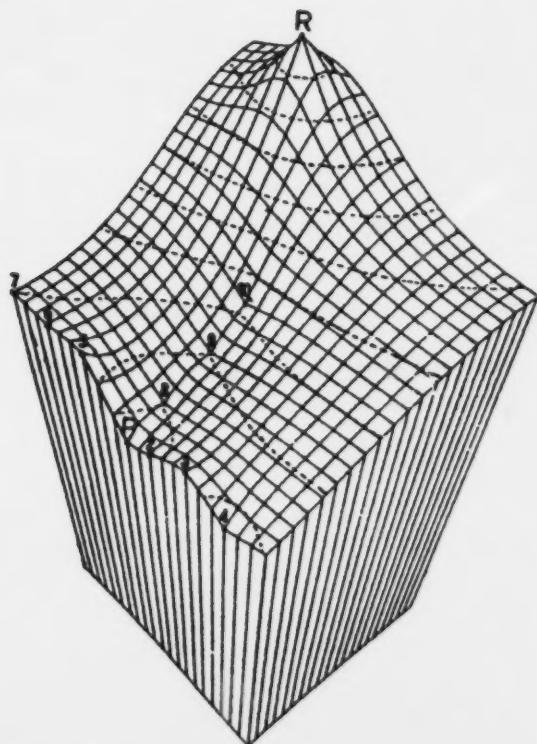


FIG: 5.19.B

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE BOTTOM, TUFTS COVE FOR
JUNE, 1985.

PLUME=7.1
REFERENCE=13.3

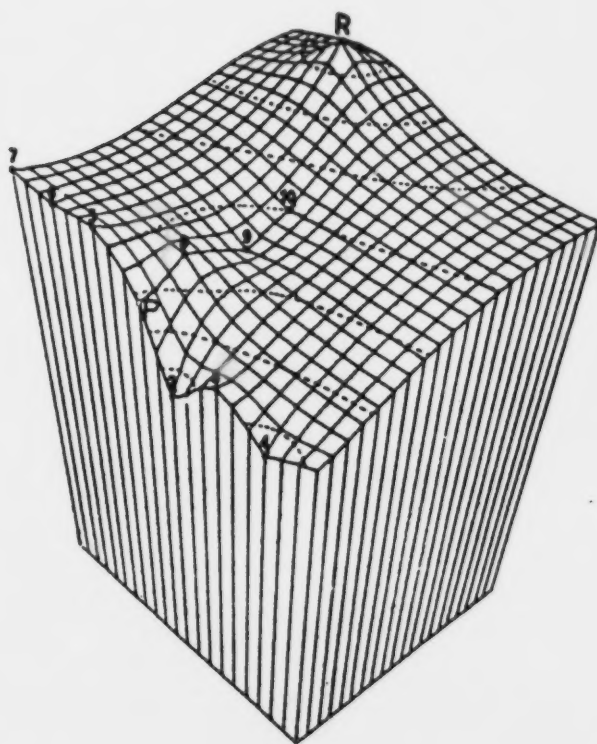


FIG: 5.20.A

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE SURFACE, TUFTS COVE FOR
JULY, 1985.

PLUME=7.4
REFERENCE=10.0

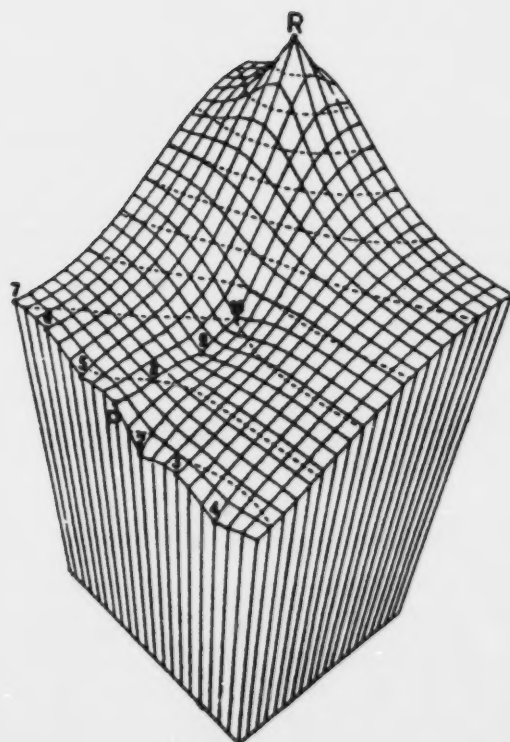


FIG: 5.20.B

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE BOTTOM, TUFTS COVE FOR
JULY, 1985.

PLUME=7.4
REFERENCE=13.3

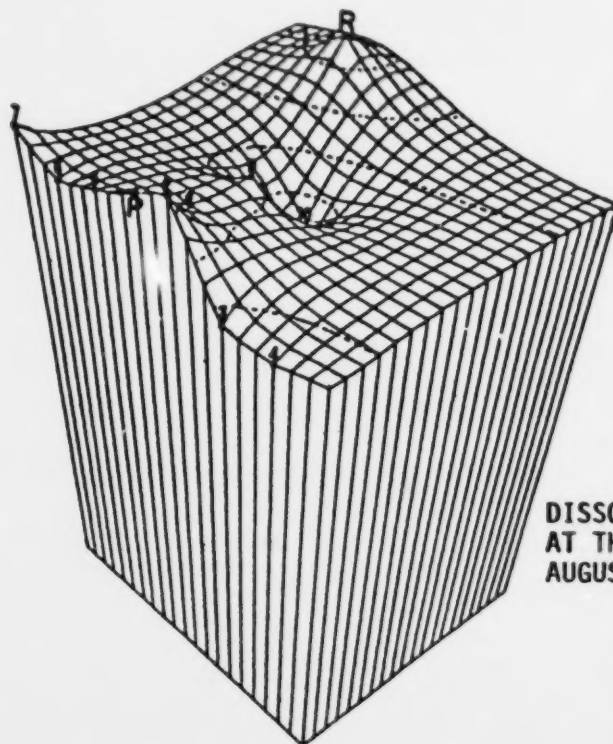


FIG: 5.21.A

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE SURFACE, TUFTS COVE FOR
AUGUST, 1985.

PLUME=9.0
REFERENCE=10.0

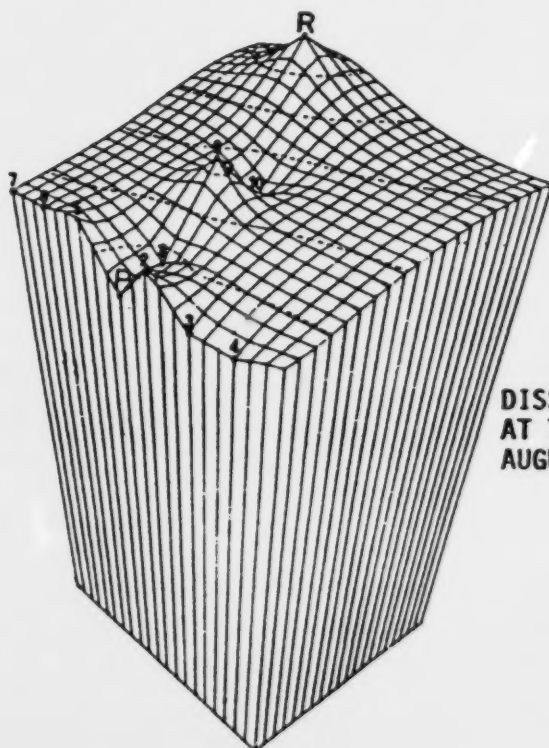


FIG: 5.21.B

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE BOTTOM, TUFTS COVE FOR
AUGUST, 1985.

PLUME=9.0
REFERENCE=13.3

and April and better temperature dependency indicated a possible water replacement between the two seasons. Surface override of sewage was present resulting in a rapid depletion of DO in the surface waters. With a careful consideration to the sewage oxygen levels, reference and plume values were in a similar range and showed a depletion of DO in the surface waters.

There was a sharp decrease of dissolved oxygen from April to May and a further drop from May to July indicating an increase of biological activities in the water column and an increase in sewage input. However, the changes were not evident for the reference sites. DO values for May ranged from 7.0 to 11.0 mg/L and correlated erratically with the water temperatures of every other station. The lowest available oxygen levels were observed during June on three separate occasions. Throughout the plume waters DO reached the critical levels of 5.0 mg/L showing a high level of depletion, with no temperature dependency. The maximum DO readings at the same time were 7.5 mg/L which was below the critical limits for summer. The greatest level of uniform depletion took place in stations 2, 3 and 4 located in the confined area of the Cove, which emphasized the inactivity of water circulation mechanisms in this area of the Cove. The trend of DO depletion continued in July with lower oxygen in the surface waters than in the bottom waters showing a clear pattern of oxygen uptake of the microorganisms in the presence of sunlight. However, in June, elevated DO levels were a clear sign of water replacement activities. The general condition of DO values in August were similar to July readings. The summer references indicated better correlation between DO and temperature, and a slight increase in available oxygen in the water columns of spring. However, the overall DO values of the Cove waters were substantially lower than the reference sites. The DO levels of Tufts Cove reached the critical level during apparent spills and throughout the late spring and summer months. Any further depletion of DO in this outfall area would be alarming.

Duffus Street

Monthly field averages and statistical analysis of daily data are presented in Table A.2.2 of Appendix A. The graphic illustration of the data are presented in figures 5.22 to 5.28 A, B and C.

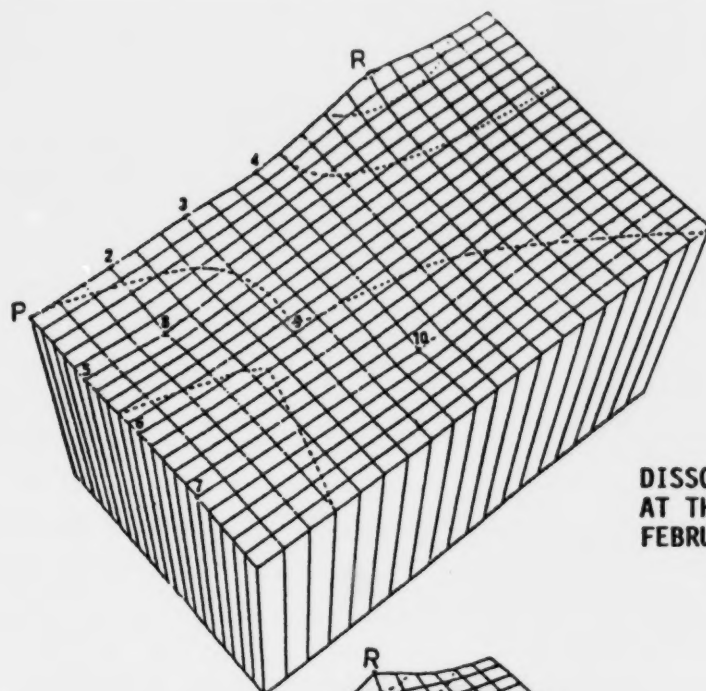


FIG: 5.22.A

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE SURFACE, DUFFUS STREET FOR
FEBRUARY, 1985.

PLUME=9.5
REFERENCE=11.1

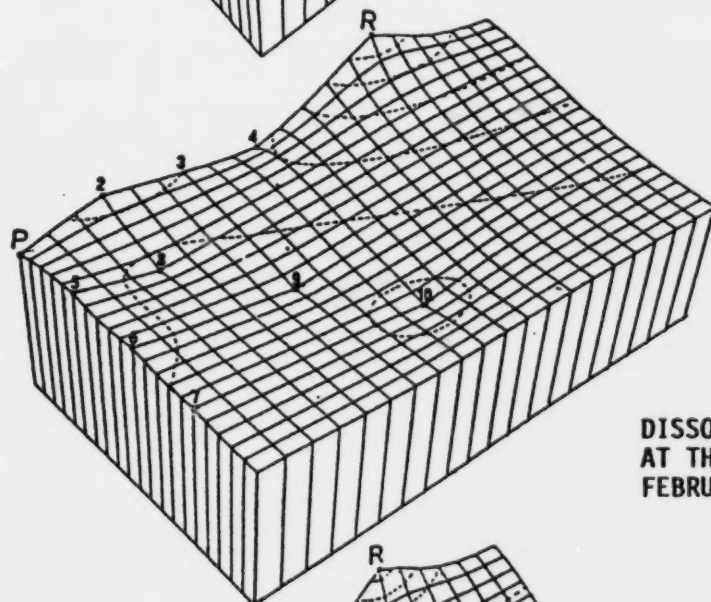


FIG: 5.22.B

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE 5 m DEPTH, DUFFUS STREET FOR
FEBRUARY, 1985.

PLUME=9.5
REFERENCE=12.0

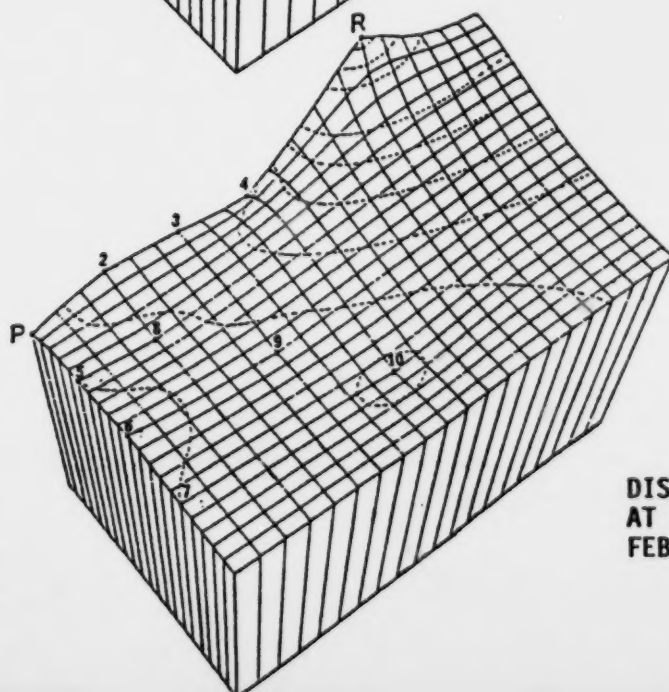


FIG: 5.22.C

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE BOTTOM, DUFFUS STREET FOR
FEBRUARY, 1985.

PLUME=9.5
REFERENCE=14.3

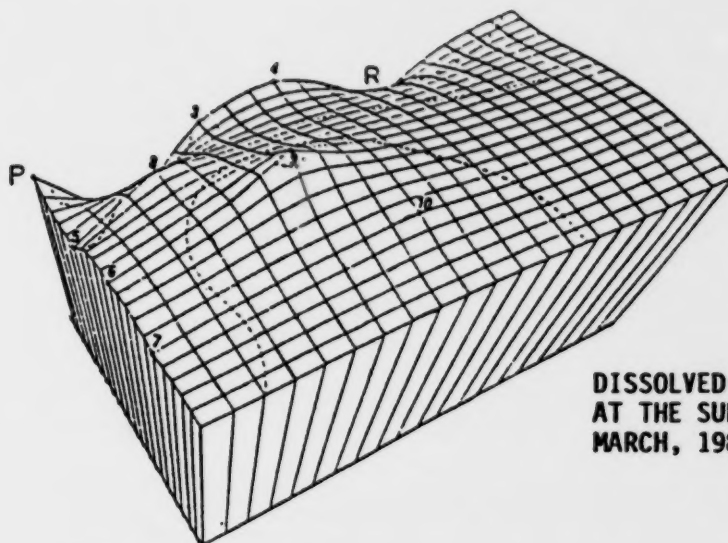


FIG: 5.23.A

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE SURFACE, DUFFUS STREET FOR
MARCH, 1985.

PLUME=10.7
REFERENCE=9.8

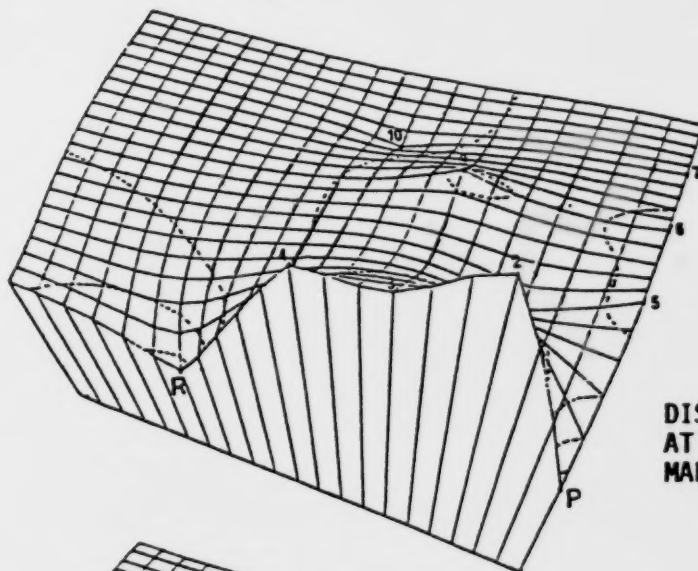


FIG: 5.23.B

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE 5 m DEPTH, DUFFUS STREET FOR
MARCH, 1985.

PLUME=10.7
REFERENCE=10.3

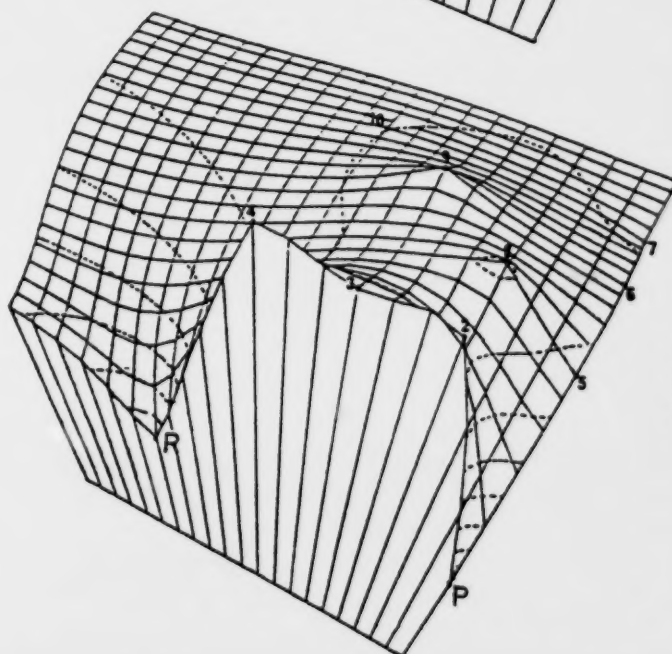


FIG: 5.23.C

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE BOTTOM, DUFFUS STREET FOR
MARCH, 1985.

PLUME=10.7
REFERENCE=10.6

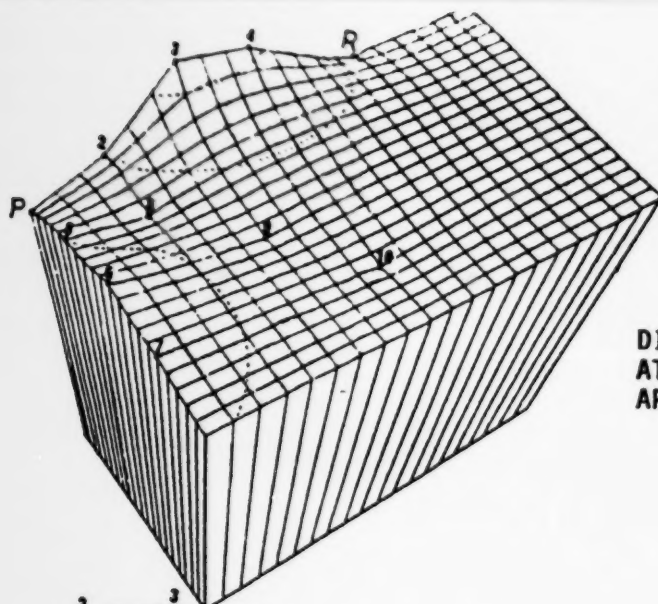


FIG: 5.24.A

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE SURFACE, DUFFUS STREET FOR
APRIL, 1985.

PLUME=9.5
REFERENCE=9.8

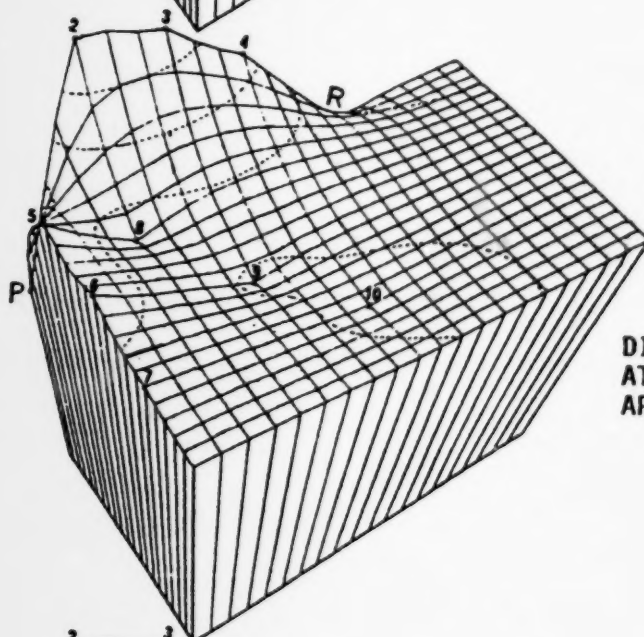


FIG: 5.24.B

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE 5 m DEPTH, DUFFUS STREET FOR
APRIL, 1985.

PLUME=9.5
REFERENCE=10.3

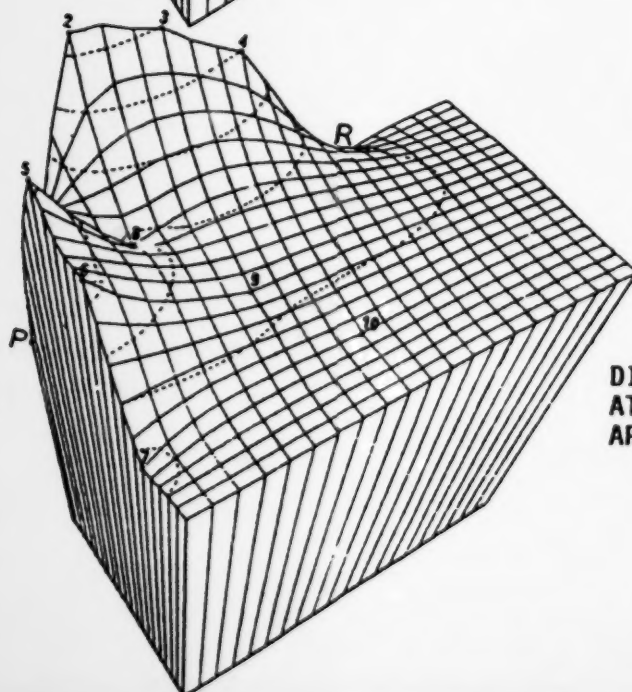


FIG: 5.24.C

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE BOTTOM, DUFFUS STREET FOR
APRIL, 1985.

PLUME=9.5
REFERENCE=10.6

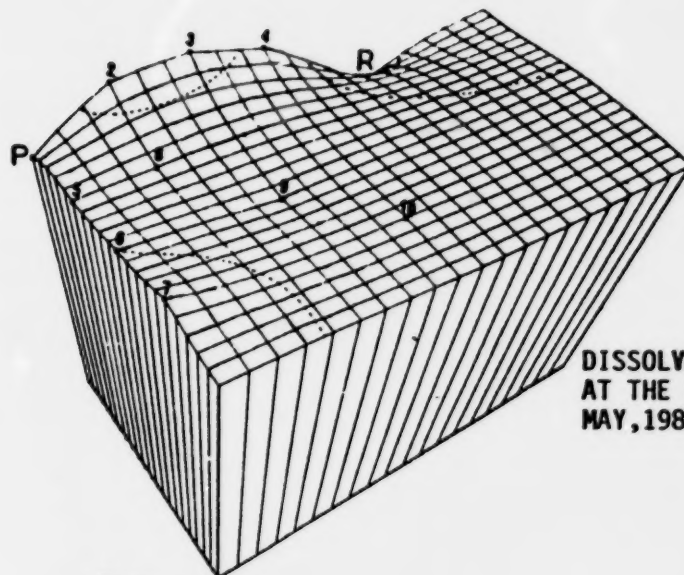


FIG: 5.25.A

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE SURFACE, DUFFUS STREET FOR
MAY, 1985.

PLUME=10.6
REFERENCE=9.8

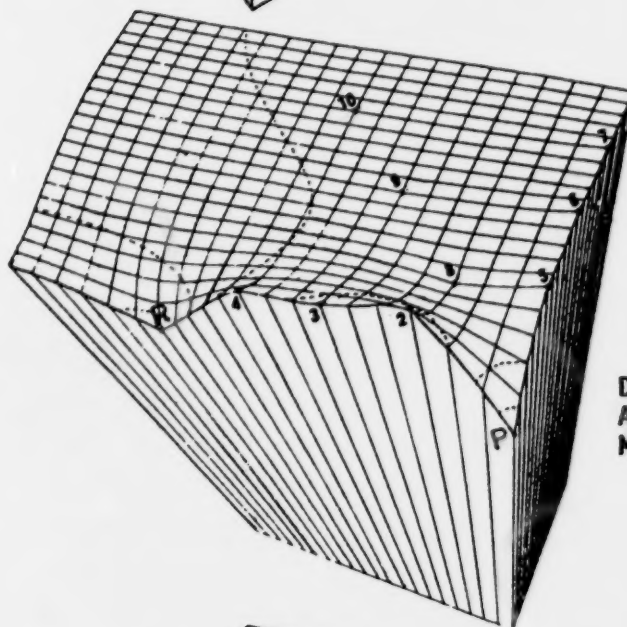


FIG: 5.25.B

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE 5 m DEPTH, DUFFUS STREET FOR
MAY, 1985.

PLUME=10.6
REFERENCE=10.3

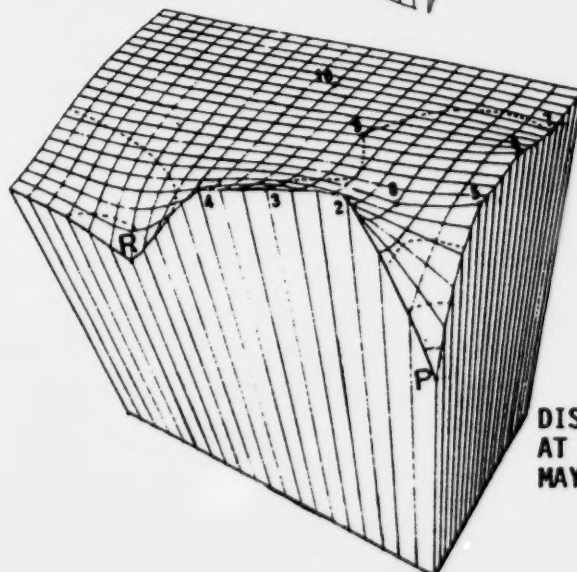


FIG: 5.25.C

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE BOTTOM, DUFFUS STREET FOR
MAY, 1985.

PLUME=10.6
REFERENCE=10.6

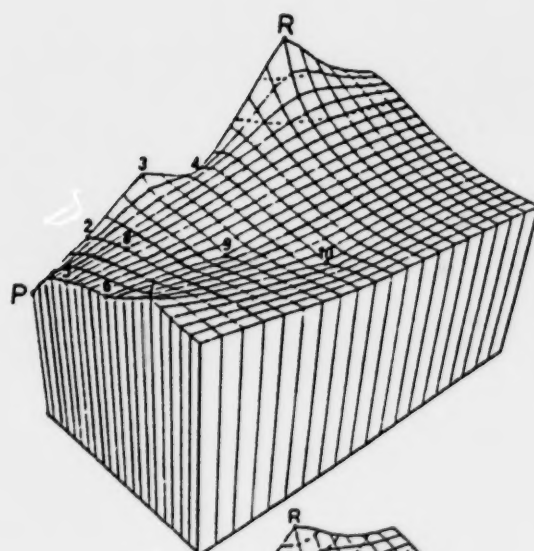


FIG: 5.26.A

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE SURFACE, DUFFUS STREET FOR
JUNE, 1985.

PLUME=7.2
REFERENCE=10.0

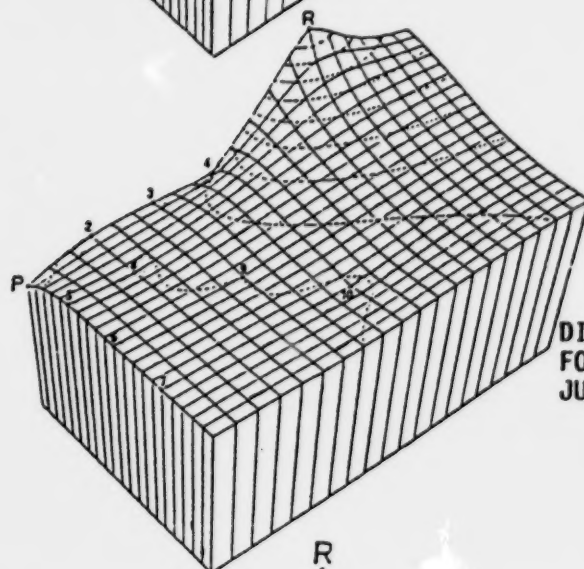


FIG: 5.26.B

DISSOLVED OXYGEN DISTRIBUTION PATTERN
FOR THE 5 m DEPTH, DUFFUS STREET FOR
JUNE, 1985.

PLUME=7.2
REFERENCE=11.6

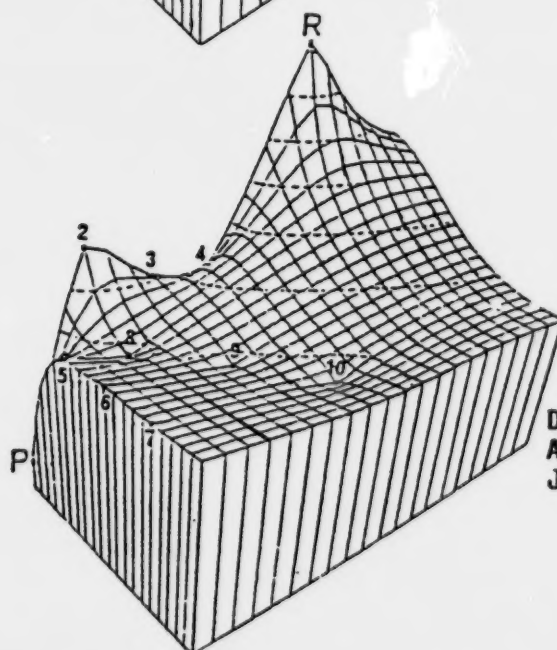


FIG: 5.26.C

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE BOTTOM, DUFFUS STREET FOR
JUNE, 1985.

PLUME=7.2
REFERENCE=12.1

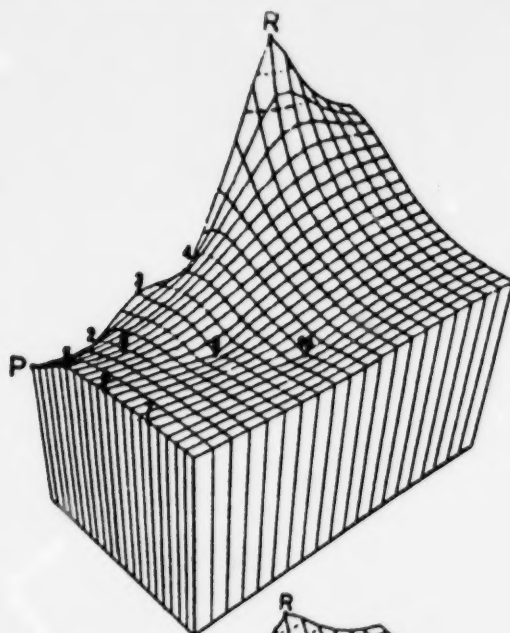


FIG: 5.27.A

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE SURFACE, DUFFUS STREET FOR
JULY, 1985.

PLUME=6.0
REFERENCE=10.0

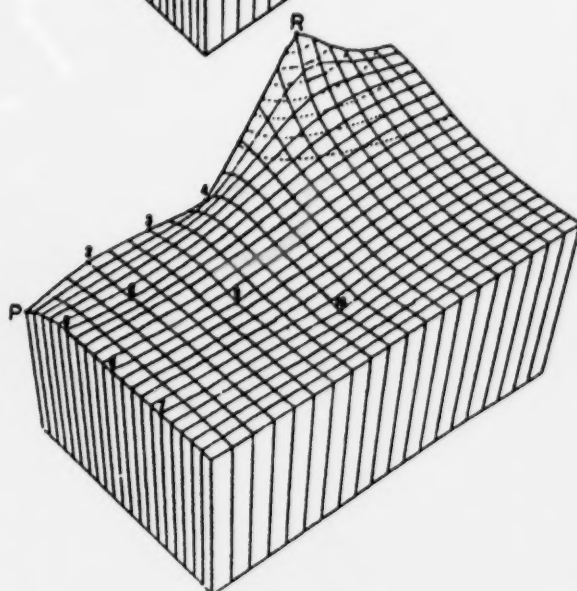


FIG: 5.27.B

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE 5 m DEPTH, DUFFUS STREET FOR
JULY, 1985.

PLUME=6.0
REFERENCE=11.6

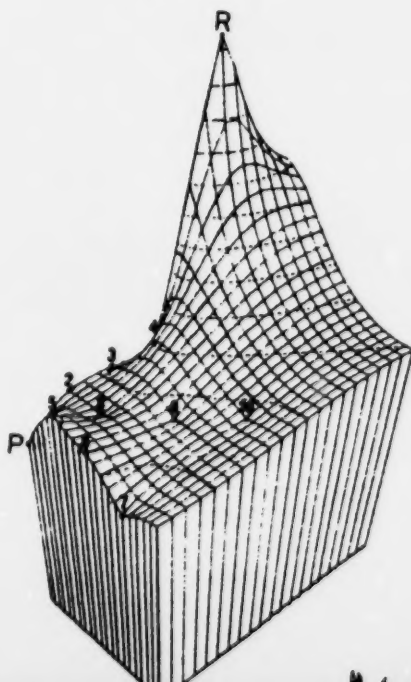


FIG: 5.27.C

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE BOTTOM, DUFFUS STREET FOR
JULY, 1985.

PLUME=6.0
REFERENCE=12.1

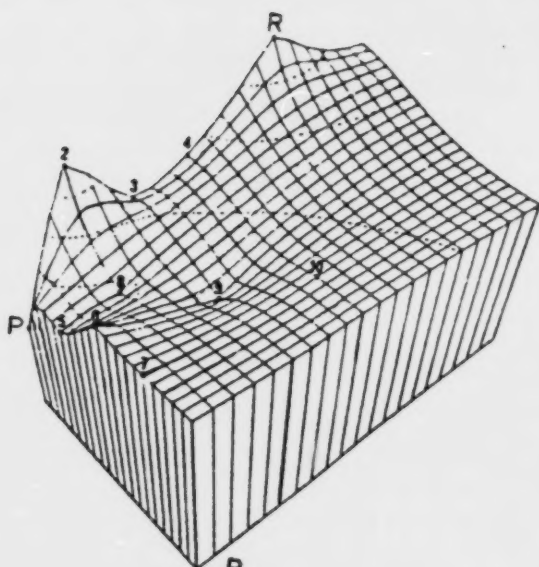


FIG: 5.28.A

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE SURFACE, DUFFUS STREET FOR
AUGUST, 1985.

PLUME=7.1
REFERENCE=10.0

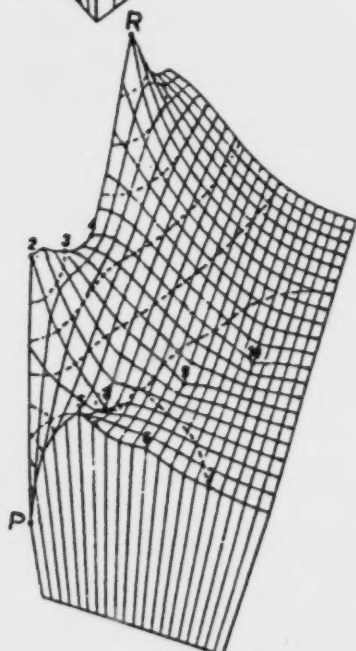


FIG: 5.28.B

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE 5 m DEPTH, DUFFUS STREET FOR
AUGUST, 1985.

PLUME=7.1
REFERENCE=11.6

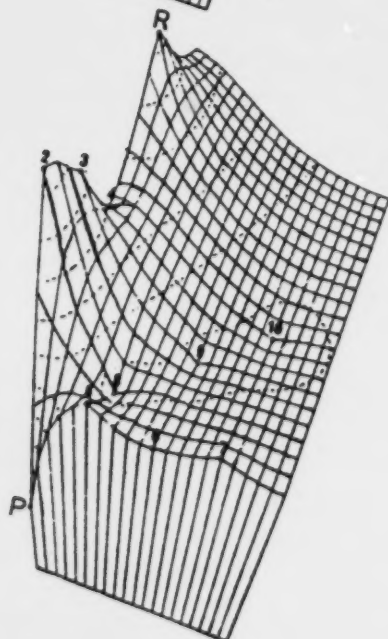


FIG: 5.28.C

DISSOLVED OXYGEN DISTRIBUTION PATTERN
AT THE BOTTOM, DUFFUS STREET FOR
AUGUST, 1985.

PLUME=7.1
REFERENCE=12.1

Dissolved Oxygen content of sewage at the point of discharge in Duffus Street was less than that of Tufts Cove. This condition could be a result of long retention time of sewage in the pipe since the contaminants had a longer distance to reach the discharge point. Therefore, oxidation of chemicals and decomposition of the contaminants had already begun.

The DO of the surface waters in February were in a similar range of the bottom waters (9.1 to 10.5 mg/L). However, there was a general depletion of DO as well as a hydrodynamic override of sewage on the upper 3-5 meters showing a thickening of this layer from 50 to 150 meter stations. The dissolved oxygen levels of the plume waters were substantially lower than the reference stations indicating a large ratio of input/removal.

The March values of DO showed the presence of substantially richer and colder waters in the bottom and a clear override of sewage with a thickness of 2 meters to the 150 meter stations. The reference stations had comparable values with those of the plume with an exception for DO rich bottom waters. This was a clear sign of water intrusion and the salinity values clarify this fact. The water columns of April and May contained less DO in the bottom waters and this was contrary to the early spring conditions. During this month the DO level of the plume waters were independent of the water temperature and contained 1.0-3.0 mg/L more dissolved oxygen than the reference stations.

During June, on one occasion, there was a cold water intrusion into the area, but the DO level did not alter as a result of it. There was a general trend of DO depletion during the summer months with the lowest observed values in July. The DO levels reached a low 4.0 mg/L and a range of 5.0 to 6.5 mg/L, during July. The pattern of distribution did not indicate a depletion of DO, but a high input to removal ratio. The summer reference DO values were substantially (4.0-6.0 mg/L) higher than the plume waters which supported the above fact. Supersaturated levels of DO were observed during August; because of the averaging of August values appeared to be higher than July readings, while in reality the daily data for August and July were similar.

The waters of Duffus Street showed a definite sign of being overloaded by a large volume of sewage input within the first 150 meters. The extent of the

low DO plume waters were not measured. However, the reference values indicate a reoxygenation from the plume waters to the middle of the Harbour. The intrusion of DO-rich waters was a partial reason for reoxygenation of the waters. During the summer months a highly critical level of DO readings were reached for the biota of this site.

Dartmouth Cove

Monthly averages and statistical analysis of the daily data are presented in Table A.2.3. of Appendix A.

Annual dissolved oxygen readings at both points of discharge were in a similar and reasonably high range of 7.1 to 11.3 mg/L. The winter values indicated a well mixed water column, yet the first 2 meters of the surface waters had slightly lower values indicating an overriding of sewage. The winter reference values were in a similar range as those of the plume waters, but in neither case was there a good correlation between DO and temperature.

Dissolved oxygen of the waters during March, April and May indicated well mixed columns; this was highly unusual and indicated a large sewage input. However, in every case the upper 2 meters of water column indicated the override of sewage. This condition dissipated in stations 9 and 10, showing a clear sign of Harbour water movement to these stations. Once, during March the discharges had unusually elevated DO levels (16.0 mg/L). The bottom waters of stations 9 and 10 showed depressed oxygen levels. The spring reference values were comparable to those of the Cove waters except for the case mentioned above.

Summer DO values were depressed compared to winter and spring values. The temperature dependency of DO, elevated biological activities and large sewage volume could be the reason for the lower oxygen levels. During June, July and August the bottom waters throughout the Cove showed a depletion of DO possibly indicating a higher oxygen demand of the bottom deposits or sewage retention. The summer reference values were 1.0 to 4.0 mg/L higher outside the Cove.

Sackville Street

Monthly averages and statistical analysis of daily data are presented in Table A.2.4 of Appendix A.

The sewage that was being discharged from the Sackville Street outfall had DO range of 7.0 to 10.7 mg/L. Vertical and horizontal mixing of sewage and Harbour waters was present during February, hence, the reference values and plume waters DO readings were similar. In neither case was temperature dependency of DO evident with the exception of the reference station bottom waters.

There was an increase of oxygen content in the plume waters from February to March and a depletion from March to August. In every case, stations 4 and 6 had high readings which were similar to those of the reference sites. During the spring months a slight override of sewage to station 3 was present. The plume water direction around stations 5 or 6 altered for every sampling occasion. The spring reference values and pattern of temperature dependency were similar to that of plume waters.

The summer DO values were relatively depressed and the lowest readings occurred during July. A general override of sewage in the upper 2 meters was pronounced. During summer the reference and plume DO readings were similar.

Pier "A"

Monthly averages and the statistical analysis of the daily data are presented in Table A.2.5 of Appendix A.

The dissolved oxygen levels of the two discharge points were in a similar range and slightly lower than Tufts Cove (6.1 to 9.2 mg/L). The oxygen content of the effluents from the sewer tunnel were lower than that of the overflow pipe.

The oxygen content in the upper 4 meters of the plume waters, for every station, were lower than the bottom waters, indicating a strong override of wastewater and sewage containment. The winter reference values were greater than the plume waters, regardless of the temperature variations of both waters.

Dissolved oxygen readings for March were elevated from that of February. The DO readings decreased steadily from March to August. An intrusion of cold, DO-rich bottom waters was evident during March which coincided with Dartmouth Cove and Sackville Street water intrusions. In April and May a strong wastewater override persisted and a sharp DO drop in these two months was pronounced. These two months had readings similar to the reference stations.

The Pier waters had substantially lower DO content in the summer months. The condition of the sewage override persisted in these waters for every month. July readings (2.4 mg/L) reached below the critical level. The expected DO recovery at stations 5 and 6 was not evident. Hence, both stations had similar characteristics and indicated lower dissolved oxygen readings than the reference stations.

In general, the waters of Pier "A" showed a low level of Harbour water circulation, since a strong hydrodynamic override persisted at all times in every station. An unusual condition of DO rich bottom waters prevailed in March which coincided with the occurrences of the other outfall sites in the wider section of the Harbour. An anoxic condition nearly prevailed during the summer months, which should be considered dangerous for biota and systematic DO depletion of the surrounding water column. The DO present in the plume waters and reference sites in a similar range only twice.

Summary

From the analysis of the dissolved oxygen data it is conclusively evident that there was a net DO depletion resulting from the continuous discharge of sewage to all the outfall sites. Furthermore, the great volume of raw wastewater disposal prevented the plume waters of all the outfall sites to reach the normal oxygen saturation or supersaturation observed in seawater. In general the velocity of sewage in the sewer pipe caused a minor reoxygenation, which was the sighted reason for the relatively high DO content of the wastewater at the point of discharge. However, in the case of the collection systems such as that of Bedford Highway Interceptor the retention and transfer time was greater; and a marked depletion of dissolved oxygen indicated a partial contaminant decomposition occurring in the sewer. The

volume and velocity of sewage resulted in continuous and strong superceding in the outfall areas. The override of freshwater sewage depleted the oxygen content in the surface waters. This condition was most evident after thermal and density stratification.

The primary reoxygenation mechanism was the water circulation that effected each outfall site independently. Infrequently, oxygen-rich cold saline waters intruded into these sites, but the predominant mechanism of DO replenishment was due to the tides and currents which resulted from local winds and movement and mixing of the reoxygenated Harbour and coastal waters to the plume areas.

There was a point of concern that anoxic conditions nearly prevailed in Pier "A" and Tufts Cove plume waters. Other outfall sites also had alarmingly low dissolved oxygen levels during the spring and summer, when biological activity escalates. The slump of biodegradation and low temperatures were the primary reason for high Dissolved Oxygen readings during winter months.

Even though the dissolved oxygen concentration of the references was within the range of 8.5 and 15.0 mg/L, the condition of the Harbour outfall sites was critical because of a large volume of sewage being discharged and little water movement or lack of reoxygenation mechanisms. These water columns had depleted oxygen levels below the recommended values of 2.0-5.0 mg/L for biota.

5.1.3 Analysis and Discussion of the Monthly Field Data of Salinity

Seawater is a relatively constant solution of ionized salts diluted in a variable amount of water. The major anions of seawater are Cl^- , Br^- , SO_4^{2-} , HCO_3^- , F^- , H_3BO_3 (semi-conservative), I^- , IO_3^- and cations are Na^+ , Mg^{2+} , Ca^{2+} , Sr^{2+} , K^+ , and Li^+ (semi-conservative). The concentration of the "conservative" ions are changed only by physical processes such as mixing, dilution, evaporation, freezing and freshwater introduction. As a result of the dynamic behaviour of oceans and estuaries, the minor "non-conservative" constituents of seawater are largely involved in the interaction with particles or microorganisms. They are being removed by turbulent processes or incorporated to sediments. Therefore, the best indicators of the actual character changes of the aquatic ecosystem are the so called "conservative parameters" such as salinity.

Salinity is the measurement of the total solids after all the seawater compounds of carbonates have been converted to oxides, bromides and iodide and replaced by chloride and organic matters had been completely oxidized. The significance of this parameter was due to the organically inert property of salt which would provide the best tracer for freshwater sewage (plume tracking), the great role of salinity in defining the density gradient (pynocline) and the effect of the density gradient on wastewater dilution rate, dispersion and ultimate removal.

Halifax Inlet system has seasonal temperature, salinity and current variations as is the case in most fjord type estuaries of the Atlantic coast that receive fresh river waters. These waters along with the upper 20 meters of coastal waters are uniformly mixed in late fall and winter (salinity and thermal stagnation). The stratification starts in spring, but a high volume of freshwater resulted from spring thaw, storm runoff and river discharges and postpones the stratification in Harbour waters. The strongest density gradients are observed during the summer months, July specifically resulting from temperature and salinity changes.

The discharge of $3.2 \times 10^8 \text{ m}^3/\text{yr}$ of freshwater from Sackville River is 1/2 to 1/5th of the total non-saline water received by this system. The

impact of freshwater influx is the existence of mean current (as discussed in section 5.4 on current), resulted from the density gradient that moves the Harbour waters to the coastal areas; there is also an overall drop in salinity readings throughout the estuary resulting from dilution of these waters. The movement of polluted and unpolluted freshwater through the Harbour is facilitated when the Inlet waters are stratified, warm, low density and salinity waters supercede the cold, dense and highly saline layers. Hence freshwater from the outfall areas and the river waters are being transported southeasterly. These flows are further facilitated by the southerly component of local winds during spring and summer that effect the surface waters. The contaminants that are trapped under the stratified layer have a lower chance of being mixed with the water column and dissipated, resulting in a rapid oxygen depletion of the bottom layers. The above conditions and the sludge bank oxygen demand influence the water quality of the plume waters substantially.

On the other hand the cold saline waters of the shelf intrude to the Harbour frequently. Their activities are not hampered by the winter stagnant waters, but the summer stratification facilitates the intrusion which removes warm, low saline and contaminant waters from the Inlet system. The salinity revival of the Harbour was greatly effected by these series of coastal water circulations during 1984-85.

The salinity of the Harbour waters were in the range of 28.0-33.0 parts per thousand (with lows and extremes of 10.0 and 35.0 ppt, respectively) this was on average approximately 5.0 parts per thousands lower than the 32.8 to 34.5 parts per thousand outside the Harbour. The present salinity readings are also lower than those reported in the 1930's and the 1950's, which further emphasizes the high input/removal rate of fresh waste, storm runoff and river waters as well as other factors. It is important to note that Parts Per Thousand (PPT) is the same as gram of salt per kilogram of water (g/kg), that will be used in this section.

Tufts Cove

Monthly averages of this field data are presented in Table A.3.1 of Appendix A. The illustration of the data is graphed in figure 5.2.9.

The salinity of the effluents at the point of discharge were in the range of 21.1 to 32.1 g/kg, these values were greater than the readings expected from the sewage. During winter and after spring storms the wastewater had elevated salinity which indicate the impact of road salt application to the in the tributary areas. This hypothesis has to be qualified by salinity readings of the manhole samples. In the absence of expected seasonal variations, the initial dilution is the reason for the high salinity of the sewage at the point of discharge.

The winter salinity readings of the stations showed a stagnant water column with a relatively uniform range of salinity readings of 29.0-29.8 g/kg, that were comparable with March values. The surface waters of stations 2, 3 and 4 indicate an override as well as pooling of the contaminated freshwater. The salinity values of the plume waters had a more irregular distribution pattern than those of the reference stations, but on an average the latter values were higher. The winter reference values indicated the override of the Sackville River waters around this area.

The distribution pattern for the spring months was highly erratic. In March the plume waters were uniformly mixed, whereas during the April sampling period shelf water intrusion increased the overall salinity of these waters. During April on occasion of heavy precipitation of the previous day, the salinity of the Cove waters reduced to 19.0 to 24.0 g/kg. Therefore, it was evident that these waters were highly sensitive to both conditions, the storm runoff and shelf water intrusion altered the salinity readings by ± 8.0 to 10.0 g/kg, susceptibility of these waters to various conditions was due to shallowness and the small volume of the Cove resulting in a rapid and a strong reaction. During May unlike the other months, the override of sewage was only evident in the times of low salinity readings. During April and May only stations 8, 9 and 10 had similar values to the reference sites, but the overall salinity values of the plume waters were lower by 1.0 to 4.0 g/kg indicating the high rate of input/removal of sewage and storm waters.

The summer readings showed a sharp drop of 1.0 to 5.0 g/kg in comparison to spring salinity values. Stations 2, 3 and 4 retained sewage throughout their water columns during June indicating little water movement into the plume area. Formation of a sudden density gradient in the Cove waters during

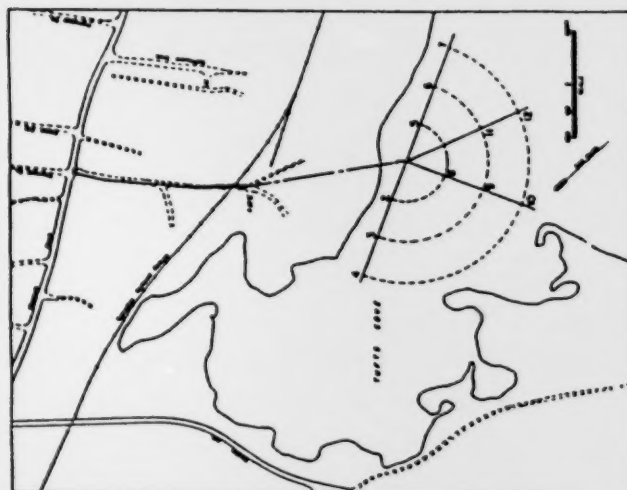
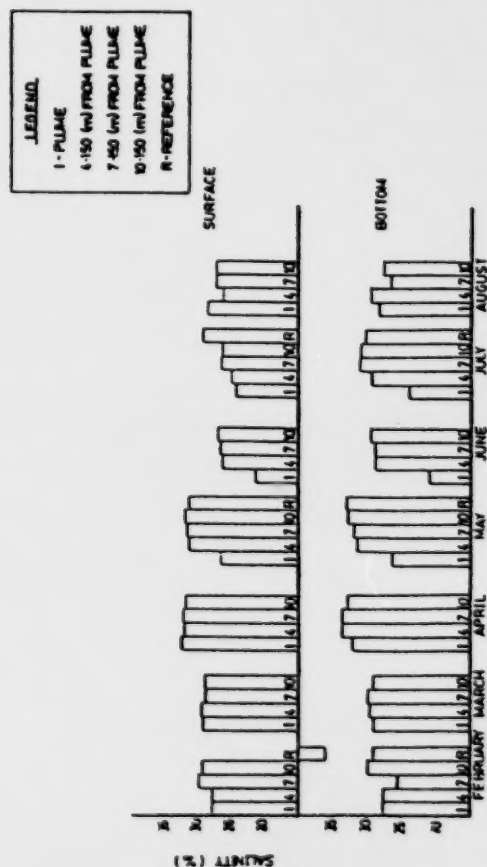
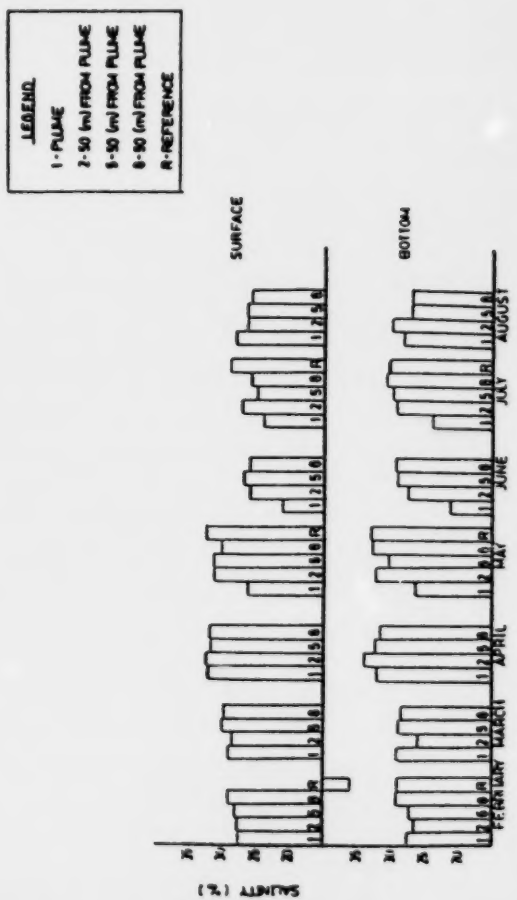
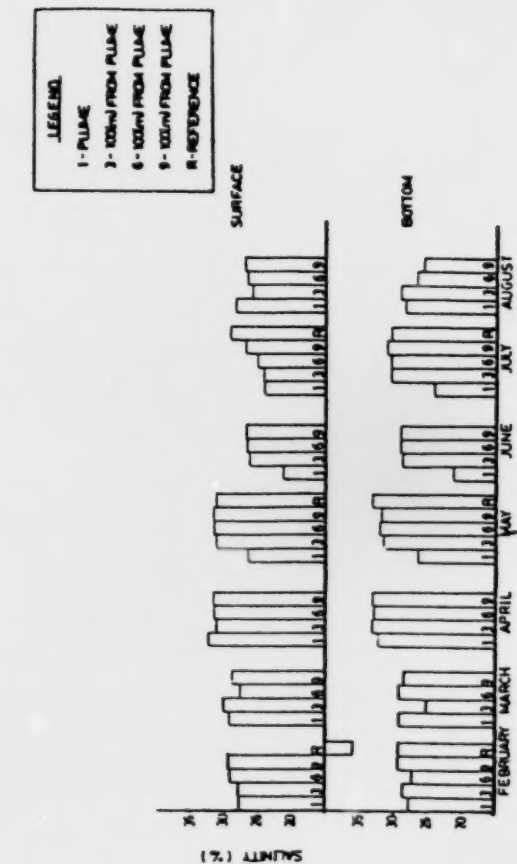


FIG-529 MONTHLY AVERAGES OF SALINITY ($^{\circ}/_{\infty}$) FOR THE STATIONS AT THE TUFTS COVE OUTFALL, 1985.

July resembled a strong override of sewage (24.0 to 25.0 g/kg values), not a stratification. This condition was prevalent in every occasion. The stratification of the Harbour might have been effecting these waters, but the volume of freshwater influx prevented formation of a pronounced density gradient. This condition was observed in August when irregular horizontal and vertical salinity readings of the water columns were also present. The summer reference values were again greater than the plume waters by 1.0 to 5.0 g/kg.

Duffus Street

Monthly averages of the field data and the statistical analysis of daily data are presented in Table A.3.2 of Appendix A. The representative graphs of the data are illustrated in figure 5.30.

The discharges from the Duffus Street outfall had a low salinity range of 18.0 to 25.5 g/kg in comparison to the Tufts Cove range. A high sewage volume and the high velocity of the sewage jet, would cause low salinity readings at the point of discharge.

The winter salinity readings of this plume showed a uniformly mixed water column as well as strong dilution within the first 50 meters of these waters. The waters of this outfall site had the same salinity readings as the reference site.

The condition of the water column during March was the same as February. An intrusion of shelf water occurred in April, this intrusion increased the average salinity by an average of 2.0 g/kg. The override of sewage prevailed twice indicating a containment of sewage in the vicinity of Halifax shipyards. The high salinity (32.0 g/kg) conditions also changed the averages of May readings, which was otherwise in the range of 22.0 to 27.0 g/kg. The sewage override was alot more pronounced during this month. The spring reference readings (at 2-4°C) were similar to the plume waters.

The summer salinity values dropped by 1.0 to 3.0 g/kg from the spring readings, this coincided with the presence of storm runoff. The stratification of these waters was observed in July, but the salinity gradient was rather weak 0.5 to 1.0 g/kg and the halocline was shallow (1-2 meters);

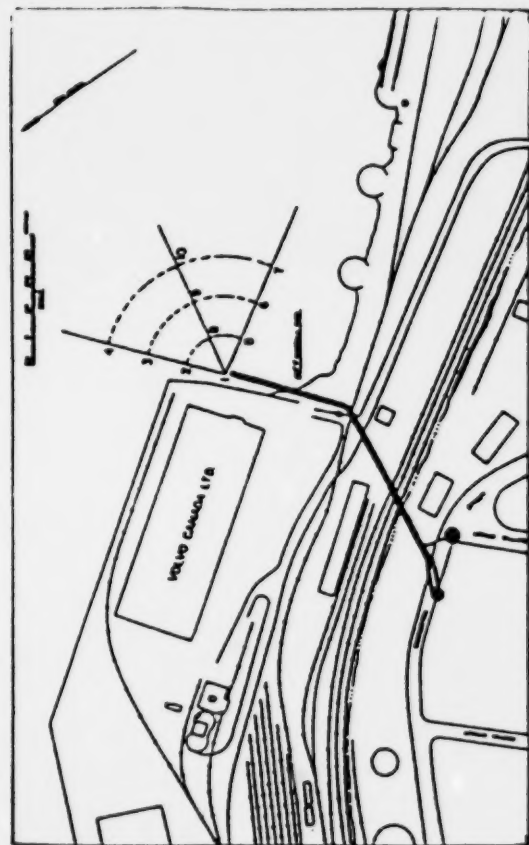
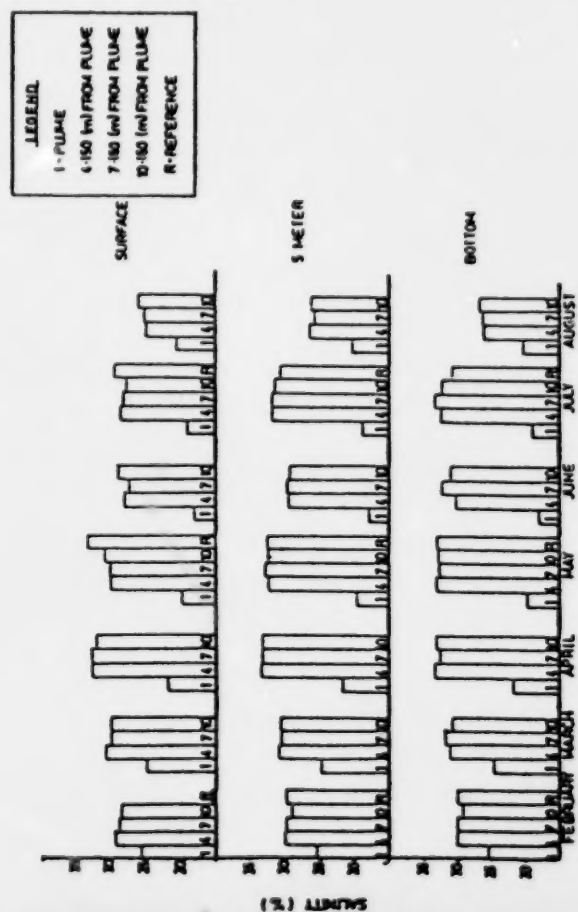
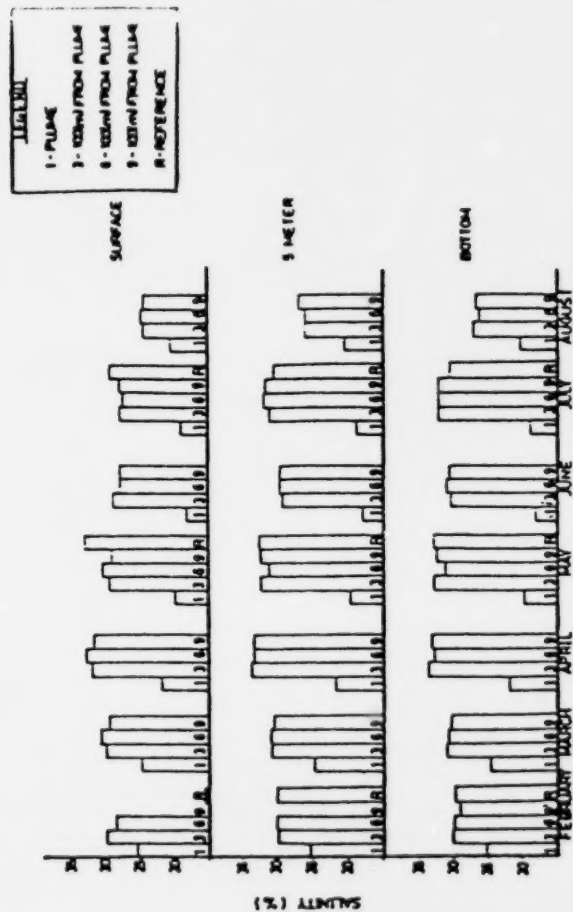
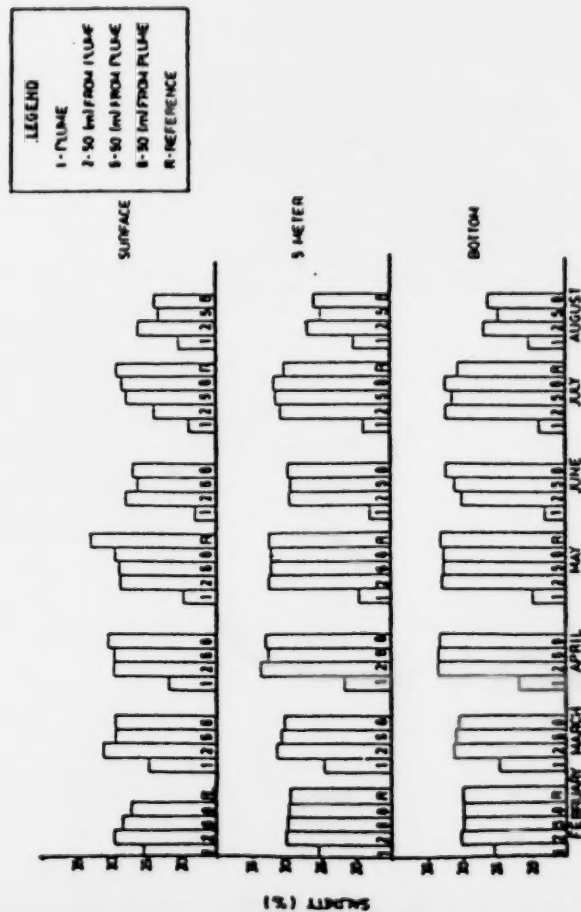


FIG.530 MONTHLY AVERAGES OF SALINITY (‰) FOR THE STATIONS AT THE DUFFUS STREET OUTFALL, 1985.

Sampling Stations at Duffus Street

hence this condition was partially due to the override of sewage. Once, during August the surface waters had very high dissolved oxygen and temperatures, but low salinity of 24.0 to 26.0 g/kg showed a great superceding of the entirety of the plume on the Harbour waters which was unusual. The stratified layer of the reference waters during summer was at the depth of 7 meters so was that of Duffus Street plume waters. The plume waters had a salinity range of 29.0 to 31.0 g/kg during June and July but the salinity dropped by 1.0 to 7.0 g/kg in August.

Dartmouth Cove

Monthly field averages and the statistical analysis of the daily data are presented in Table A.3.3 of Appendix A.

The salinity values at the point of discharge were in the range of 19.3 to 31.0 g/kg showing no seasonal dependency. Relatively low velocity of the sewage jet would allow a better initial dilution.

Salinity values during winter did not indicate uniformal readings for Dartmouth Cove as was present throughout the Harbour. Plume waters had three different salinity ranges within 25.0 to 30.5 g/kg in February over emphasizing the impact of a large volume of sewage on the shallow section of the Cove.

Two conflicting salinity ranges were present during March, on one occasion the readings were in the range of 15.0 to 27.0 g/kg, another time the range of 27.0 to 32.5 g/kg; showing the sensitivity of these waters to any changes due to Harbour water movement or storm runoff and flow resulting from the spring-thaw. Shelf water intrusions of April and May effected the salinity values of the Cove (salinity = 34.0 g/kg), and coincided with the sewage override. After the shelf water intrusions, the salinity of the plume water columns were similar to reference stations, otherwise the Cove waters due to high input/removal rate had depressed salinity readings.

During the summer a sharp decrease of 1.0 to 7.0 g/kg in salinity from spring values was present. Stratification of the plume waters was best demonstrated in August. The salinity gradient of the upper 2 meters of these

waters also resembled the override of sewage more than stratification. The August values were similar to the references, but the depth of the pynocline of the outfall waters was only 3-4 meters.

The plume waters obviously did not have the capacity to assimilate the wastewater and storm runoff. The behaviour of the waters in this area in relation to the density, showed signs of overloading, and susceptible to drastic changes

Sackville Street

Monthly field averages of the statistical analysis of the daily data are presented in Table A.3.4 of Appendix A.

The salinity values of the discharge point were in the range of 17.0 to 28.0 g/kg. The salinity values of the 75 meter station water columns indicated a very rapid dilution of the sewage to the salinity readings of the reference stations.

The winter density stagnation of the water column was evident. Cold water intrusions were observed in every month of spring. The summer stratification began in June with an average depth of 3-4 meters till August. In this period the hydrodynamic override of sewage was evident.

During every season the reference values and the plume water salinity readings were similar. The density of the waters of this outfall site were not effected by sewage disposal.

Pier "A"

Monthly averages and the relevant statistical analysis of the daily data are presented in Table A.3.4 of Appendix A.

The salinity of the sewage at the point of discharge was within a range of 15.0 to 26.0 g/kg, and showed a sharp increase of 1.0 to 8.0 g/kg within the first 200 meters for every season except summer. Reasons for such low

salinity readings at the point of discharge were low velocity of the discharges as well as inactivity of Harbour water movements due to high volume of sewage input into the area.

The winter values showed density stagnant water columns within both plume waters. In winter as well as in spring the override of sewage was more pronounced on the waters of plume 2. The cold water intrusion during the spring was also more evident in the waters of plume 2 which changed the water columns throughout the area. The reference values were in a similar range as those of the plume waters for February and May.

The summer salinity readings were highly irregular. During June each section of the water column of each station had a different salinity range; hence no clear pattern of distribution existed. During July and August there was no stratification evident. A pynocline and a density gradient was not evident. The salinity of these waters gradually increased, commencing at the surface to the bottom of the water column. Even though the salinity data of Pier "A" shows a range of 28.6 to 33.0 g/kg, the impact of a large volume of sewage on the confined outfall area was evident.

Summary

The salinity of the Harbour waters to a large extent facilitates the movement of sewage contaminants by stratification, and the physical hydrodynamic superceding of the sewage on the saline plume waters. The impact of freshwater on the Harbour waters had already been discussed. The contaminated sewage effected the formation of a thermocline, and also resulted in the elimination of a density gradient within the plume waters.

Unusual conditions were present in Tufts Cove, Dartmouth Cove, Pier "A" and Duffus Street, reasons being the volume of sewage, velocity of the discharges, volume and depth of the receiving waters plus their accessibility to Harbour water movements. The override of plume waters was the norm in every site except Sackville Street. The storm runoff and spring thaw only effected some outfall sites. The shallower outfall sites with low Harbour water circulation increased the susceptibility of these sites to changes. Therefore, Tufts Cove, Dartmouth cove and Pier "A", showed great levels of

sensitivity to cold water intrusions, storm runoff and spring thaw discharges. However, a quantitative analysis of the salinity of the manhole sewage samples are needed to qualify the impact of storm runoff as well as road salting and spring thaw discharges on the sewage salinity before initial dilution.

5.1.4 Analysis and Discussion of the Monthly Data for Conductivity

A measure of the ability of any solution to carry an electrical current, is the measure of the conductivity of water. The conductivity reading of any solution varies with the number and type of ions present in the water. Hence, the Total Concentrations of cations and anions present in the solution results in a measure of its capacity to conduct electrical currents.

The Relative Concentration of the conservative ions in the seawater remains the same; an approximate 35% of seawater constituents are ionic salts. The major ionic constituents and their relative concentrations are: sodium .463 moles/liter, chloride .546, magnesium .053, calcium .010, potassium .010, sulphides .028 moles/liter and iodide .2 to .5, bromide 84.0, carbonates 2 to 25, boride 4.0. fluoride 68, lithium 25 and stranthium 90 micromoles/liter. Carbonates and stranthium have variable concentration depending on the rate of biological activities in seawater. All the ions mentioned above yield a special conductivity reading, which shows a strong correlation with temperature and salinity, since salinity is also a measure of the major salt content of seawater.

The measurement of conductance in seawater contaminated with sewage is a function of water temperature, concentration of suspended particles, season of the year and the biochemical conditions of the plume water. An approximate change of 1°C in water temperature changes the conductivity reading by 2%. The suspended particles increase the resistance and decrease the conductivity readings. Hence, presence of suspended solids of certain sizes with specific external ionic charges as well as planktons alter the conductance of the plume waters. These factors explain the seasonal dependency of the conductivity

reading. The salinity changes due to intrusions, upwelling of the supernatants of the sludge deposits and downwelling of fresh sewage also alter conductance. The spring thaw, road salt, storm runoff and atmospheric fallout alter the conductance of the coastal waters drastically.

Measurement of the conductivity of plume waters with a pH range of 6.0 to 9.0 provides a very valid tool for tracing the dispersion of the sewage. Fresh wastewater alters the water quality in the vicinity of the outfalls on two levels: first, the quality of the water column alters as a result of dilution of seawater with freshwater (conductivity = $1/\text{resistance of water}$) which increases the conductance, but the dissolved salts of contaminated freshwater increase the resistance and decrease the conductivity readings; second, the sludge banks release dissolved acids and other supernatants that alter the water quality of the bottom plume waters. These are the reasons for considering conductivity as a tracer of the fresh wastewater in the near field. This parameter is not a standard test for assessment of plume water quality; hence no limitations are cited. However, the limits for salinity of estuarine waters are 32 mg/L and the dissolved solids standards are 30 to 50 mg/L.

Tufts Cove

Monthly averages of the conductivity data and relevant statistical analysis of the daily readings are presented in Table A.4.1 of Appendix A. The graphical representations are in figures 5.31 to 5.33.

The conductance of the sewage at the point of discharge was within the range of 23,170 to 31,500 $\mu\Omega/\text{cm}$. The comparable salinity and suspended solids indicate a very strong seasonal and particulate dependency showing a very susceptible water column. It was evident that the concentration of dissolved solids in these cases were high.

The conductivity of the plume waters during April showed a narrow range of variation (27,000-28,400 $\mu\Omega/\text{cm}$). The surface waters indicated a strong override, and the bottom waters received dissolved components from the sludge banks. Hence the water column had three different conductance ranges. This

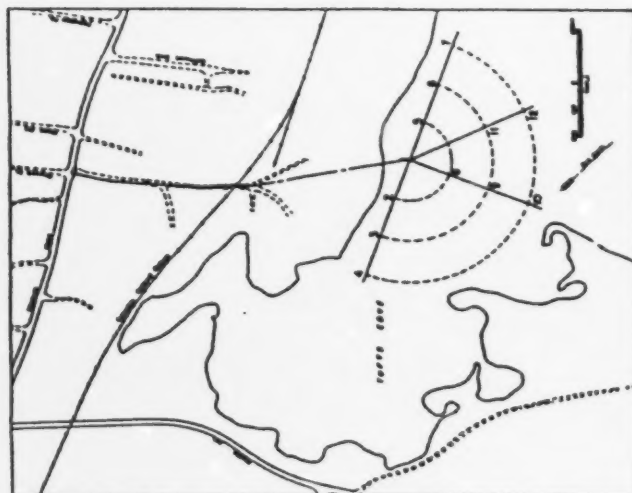
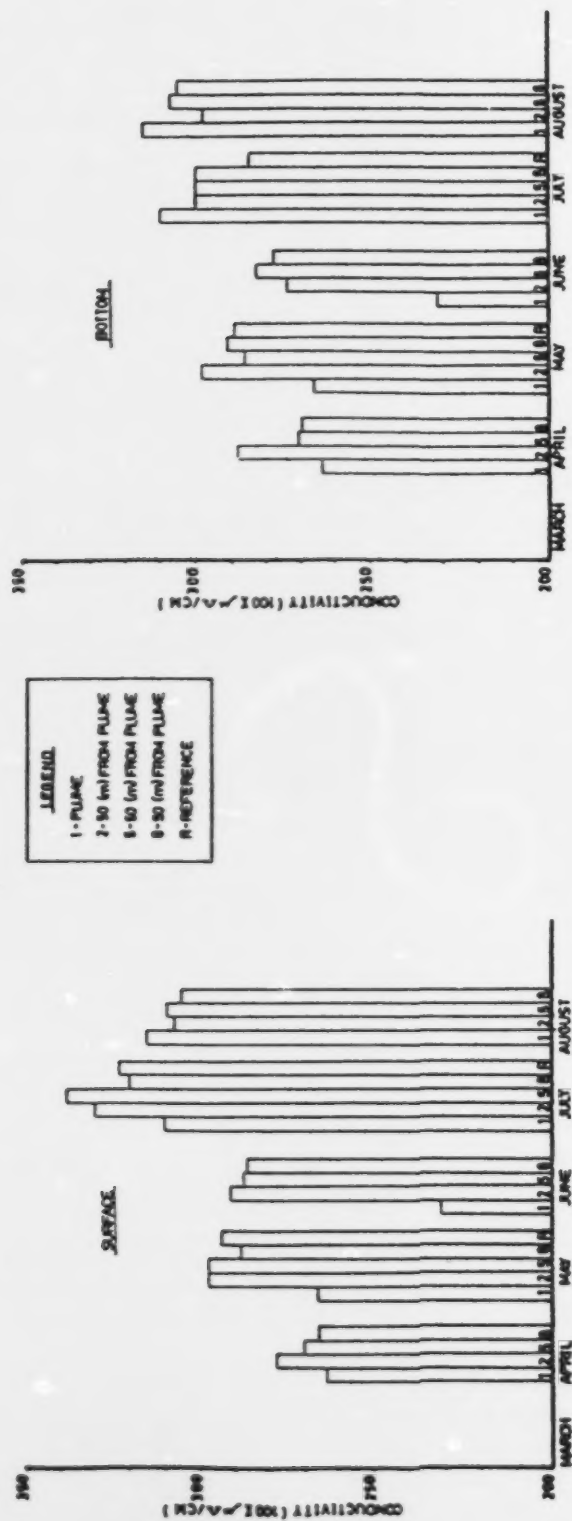


FIG-531 MONTHLY AVERAGES OF CONDUCTIVITY ($\mu\Omega/\text{cm}$) FOR THE STATIONS 50 m AWAY FROM THE PLUME AT TUFTS COVE, 1985.

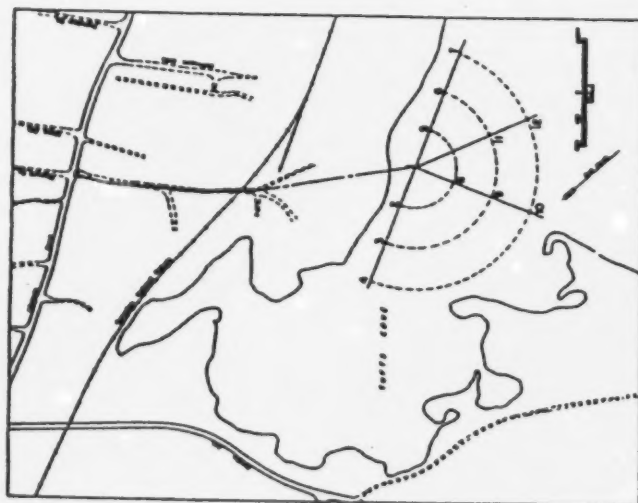
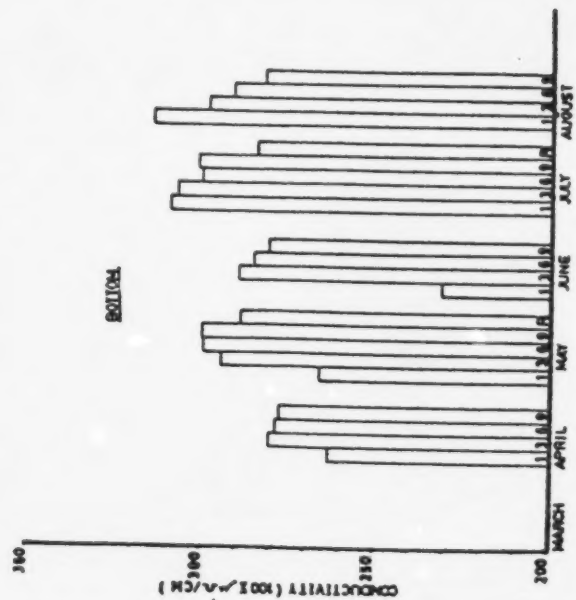
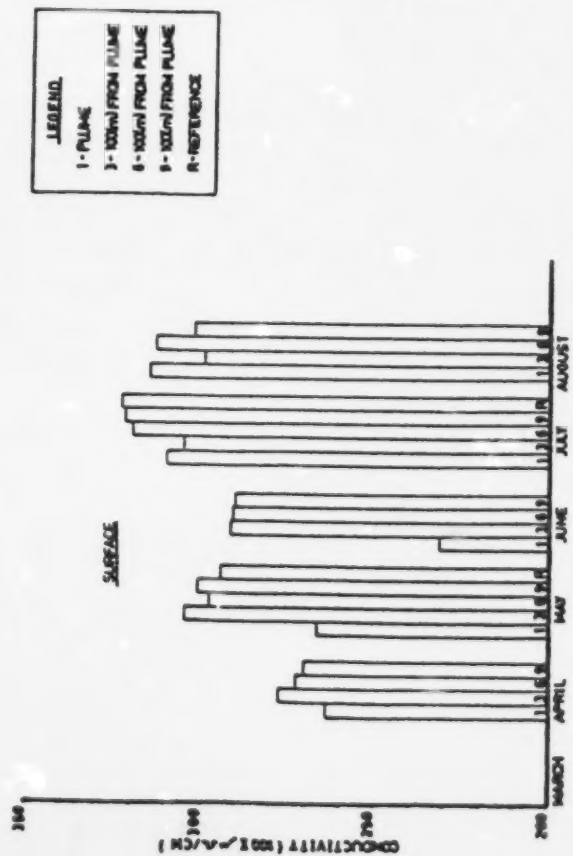


FIG-132 MONTHLY AVERAGES OF CONDUCTIVITY ($\mu\Omega/\text{cm}$) FOR THE STATIONS 100 m AWAY FROM THE PLUME AT TUFTS COVE, 1985.

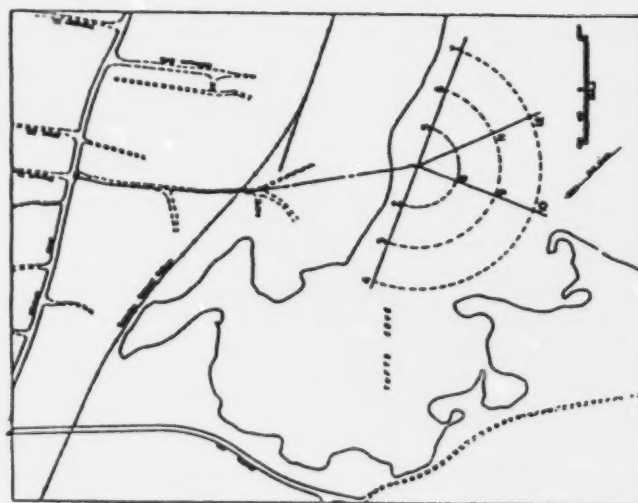
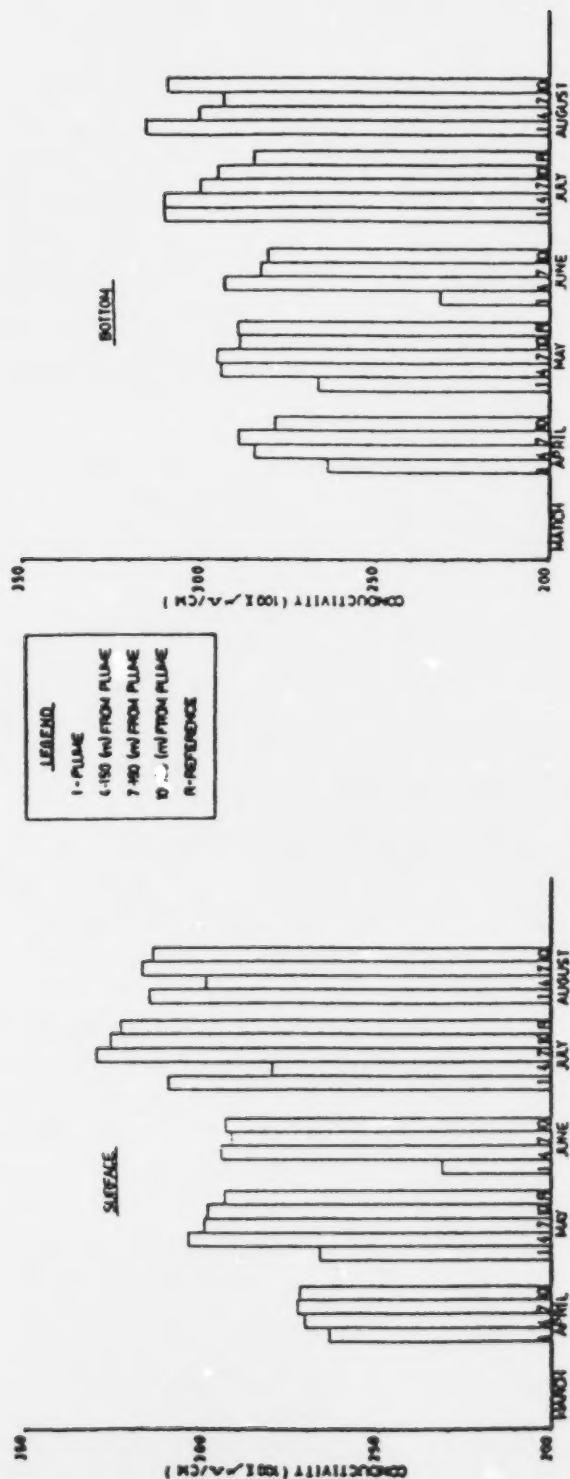


FIG:5.33 MONTHLY AVERAGES OF CONDUCTIVITY ($\mu\Omega/\text{CM}$) FOR THE STATIONS 150 m AWAY FROM THE PLUME AT TUFTS COVE, 1985.

condition also prevailed in May, with the exception that the range of variation was 28,000 to 30,500 $\mu\Omega$ /cm. In neither April nor May was the conductivity the same as the reference stations.

The elevated biological activity, increase in temperature and high dissolved solid content of plume waters in June and July caused a depletion of Tufts Cove water quality. The bottom sludge activity further hindered these conditions. Even though, there was a slight improvement in conductivity readings present in August, the correlations between this parameter and temperature and suspended solids was weak. This condition indicated an overall and continuous deterioration of the water quality of the Cove from spring to summer. The reference values were not reached during the summer months.

The general condition of the Cove waters according to this parameter only, improved on two occasions of shelf water intrusion, however and this relatively balanced condition lasted for a short period of less than two weeks. The dissolved solid content of sewage and the plume waters remained high at all times. The sewage override and movement of the sludge supernatant was also evident continuously. The spring plankton bloom and storm conditions also altered these readings.

Duffus Street

Monthly field averages and relevant statistical analysis of the daily data are presented in Table A.4.2 of Appendix A. The graphical illustration of the data are in figures 5.34 to 5.36.

The conductivity of wastewater at the point of discharge was in a wide range of 15,000 to 27,350 $\mu\Omega$ /cm. There was clear evidence of conductivity variation at the point of discharge after storms and during spring thaw. A strong correlation of 98% was established between the initial conductivity, suspended solids and salinity at this point.

During early spring (March and April) the water columns had uniform conductivity readings, except for the bottom 2 meters of the plume waters which showed signs of the presence of large amounts of dissolved solids.

Override of sewage was evident but not as prevalent as in Tufts Cove. Stations toward the Halifax Shipyard indicated a higher content of sewage contaminants. There was a general trend of higher conductivity readings from spring through summer. The May readings show the impact of shelf water intrusion on the revival of the conductivity and salinity readings, as well as the effect of spring thaw, storms and phytoplankton activities on reducing the conductance. Each water column had variable ranges of conductivity readings and this was more prevalent in the first 50 meters. The spring reference values were only comparable to the conductivity readings of May.

An increase in sludge activity during the summer months decreased the conductivity below the pycnocline at the 7 meter depth. Hence the supernatant of the sludge was trapped and mixed within the water column only when the Harbour water circulation effected this outfall site in early July. During July, because of conflicting forces within the plume waters, conductivity of the water columns was highly irregular and in a wide range of 22,000 to 39,000 $\mu\Omega$ /cm. Resultant correlation of the conductivity with suspended solids and temperature was weak. This condition was not present during August and the water columns only had a high concentration of dissolved salt in the bottom 3 meter layer. The summer references were similar to the outfall readings for July, on one occasion, whereas during the remaining period these readings were well below the reference readings.

Although, the Duffus Street outfall had a mean depth of 15.0 meters the plume waters showed a sensitivity to storm runoff, spring thaw and Harbour water circulation. The level of dissolved solids emanating from this sewer was moderately high. The sewage override was evident within the first 100 meters. There was a compound impact of the density gradient and sludge activity on the water columns.

Dartmouth Cove

Monthly averages of the field data and the statistical analysis of the daily results are presented in Table A.4.3 of Appendix A.

The conductivity of wastewater at the point of discharge was in a wide range of 13,000 to 38,000 $\mu\Omega$ /cm. Low readings were more frequent during spring thaw and storm events.

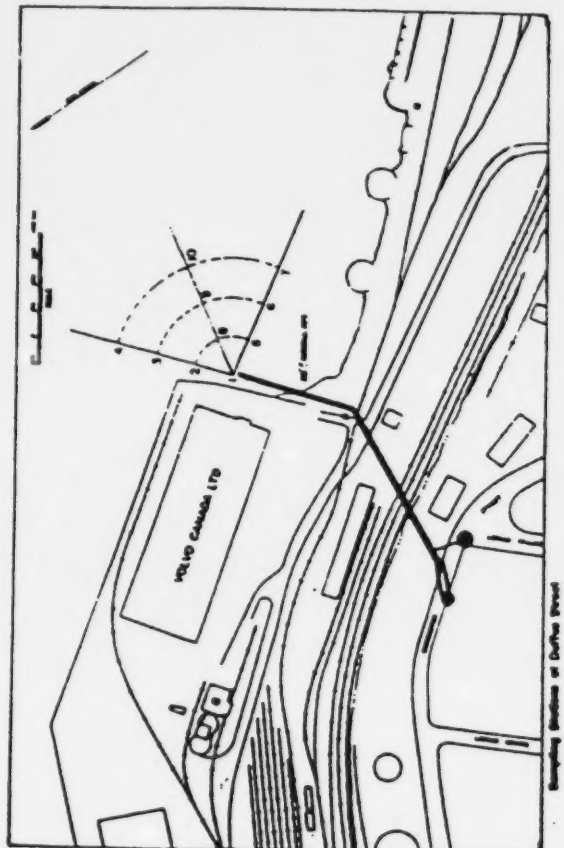
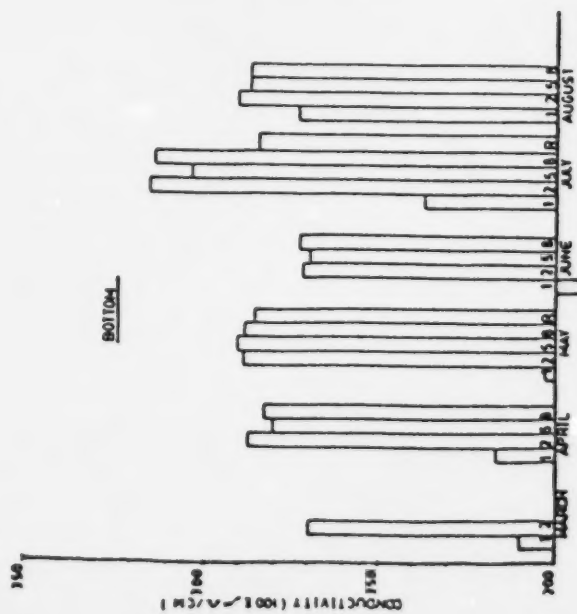
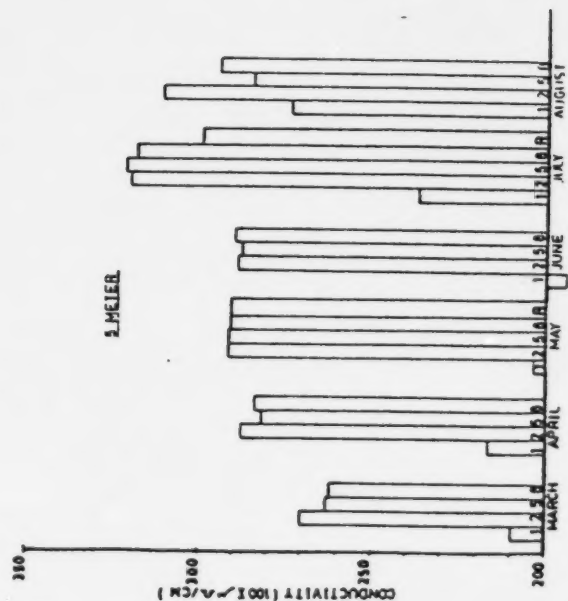
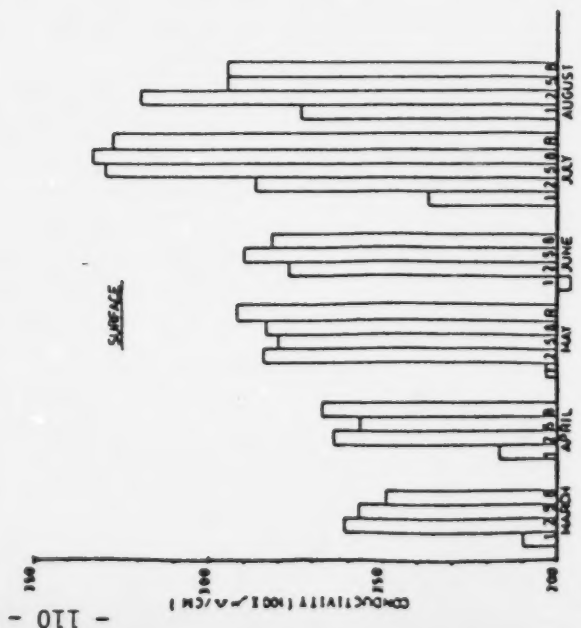


FIG. 5.34 MONTHLY AVERAGES OF CONDUCTIVITY ($\mu\text{S}/\text{cm}$) FOR THE STATIONS 50 m AWAY FROM THE PLUME FOR DUFFUS STREET, 1985.

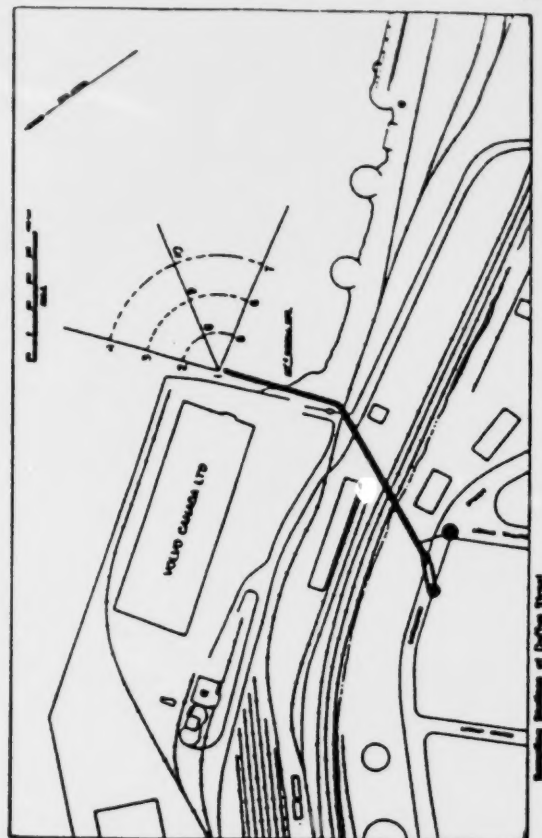
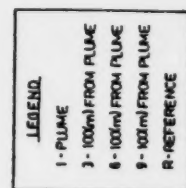
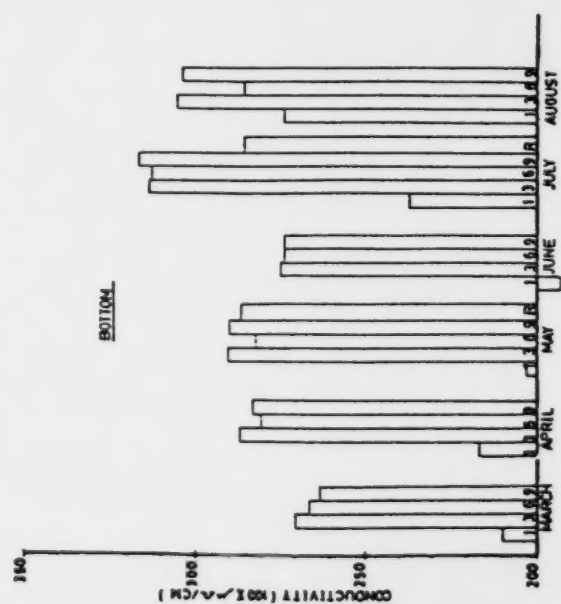
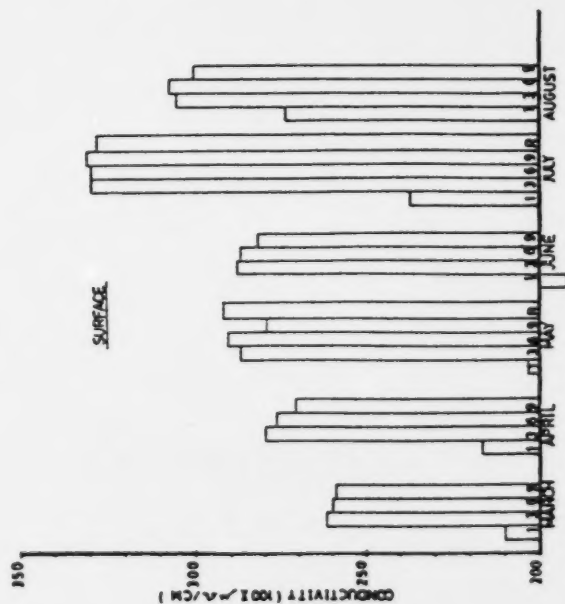


FIG-5.35 MONTHLY AVERAGES OF CONDUCTIVITY (μS/cm) FOR THE STATIONS 100 m AWAY FROM THE PLUME AT DUFFUS STREET, 1985.

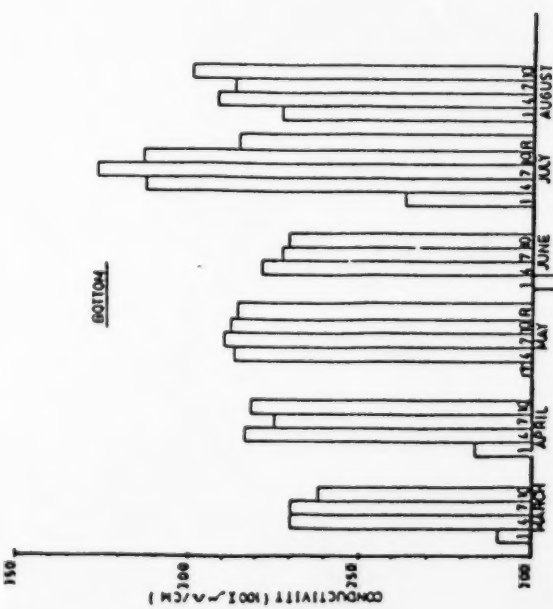
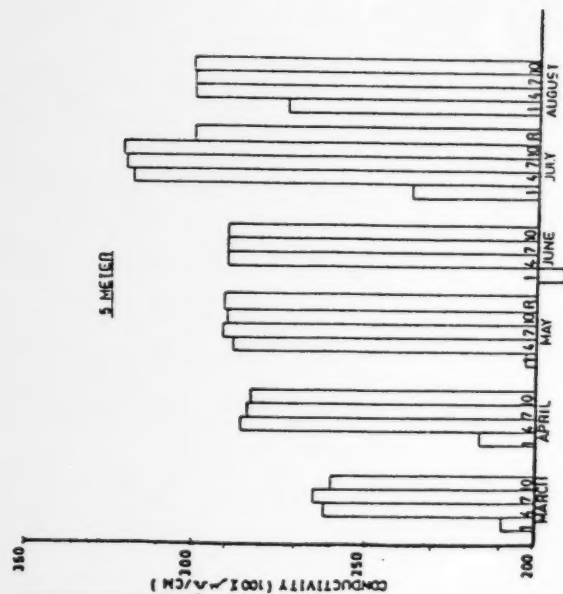
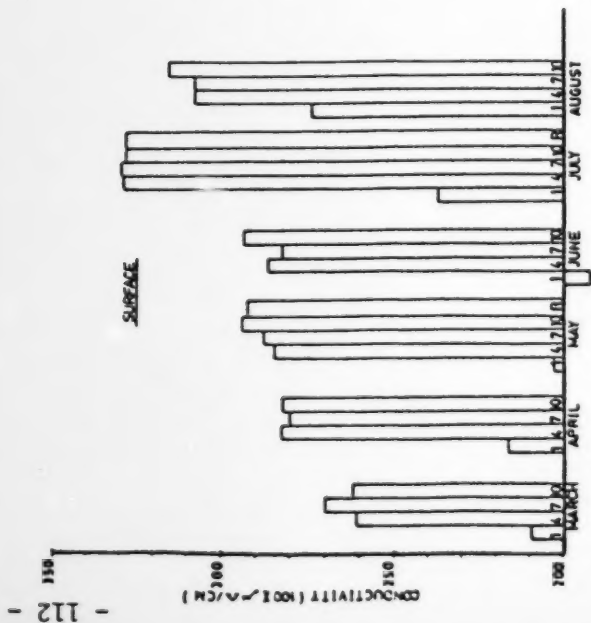


FIG: 5.36 MONTHLY AVERAGES OF CONDUCTIVITY ($\mu\text{S}/\text{CM}$) FOR THE STATIONS 150 m AWAY FROM THE PLUME AT DUFFUS STREET, 1985.

During March and May a strong override of sewage transported the dissolved solid content of the effluents 200 meters from the point of discharge. The dissolved solids content of the water column and sludge activities were elevated during May. Plume waters receive shelf water up to 50 meters from the Maitland Avenue sewer discharge point, during April and May, causing a general trend of water quality improvement after shelf water intrusion. A continuous depletion of water quality prevailed until the water circulation mechanisms of the Harbour reached the Cove. The reference readings were in the same range as those of April's only.

Warming of the plume waters enhanced the biochemical activities within the sludge deposits, hence during the summer months the bottom 2 meters of most stations contained large amounts of soluble supernatants and conductivity of this layer was lower than the water column. The surface override of low conductance wastewater on the plume waters was evident. The water quality deteriorated from spring to summer and the worst conditions were present during June and July. The summer reference readings were not readily comparable with that of the plume waters since they differed by 1,000 to 5,000 $\mu\Omega$ /cm.

The pattern of conductivity readings of Dartmouth Cove was erratic. Unusually well mixed water columns during April and a sudden change after the shelf water intrusion as well as spring thaw and storm runoff effected the 100 meter stations and up to 100 meters farther than stations 9 and 10 which were located in deeper waters. Therefore, input/removal ratio of the outfall site and Harbour water circulation governed the water quality of shallow sections of the Cove. A heterogenous conductivity reading in these waters was resulted from dissolving the sludge bank supernatant in bottom waters and the override of sewage on the surface.

Sackville Street

Monthly field averages and the relevant statistical analysis of the daily data are presented in Table A.4.4 of Appendix A.

Conductance of the discharges from this outfall were in the range of 20,000 to 32,000 $\mu\Omega$ /cm which showed an immediate dispersion of sewage.

The soluble solid content of the water column during March and April was low; hence the conductance, salinity and temperature were well correlated. Override of sewage was evident within the first 75 meters. The conductivity readings in May were higher than the previous two months indicating a shelf water intrusion. During spring the surface waters showed superceding of sewage in progress and the bottom waters contained a large amount of sludge supernatant. Hence 2 meters of the bottom waters and 2 meters of the surface waters were significantly effected by raw sewage disposal (average depth is 17.0 m). Reference waters had a higher conductance ability and less resistance compared to the plume waters.

The warming of waters in summer time caused the formation of a thermocline and an increase in biochemical activities. Both these conditions resulted in an alteration of the conductivity readings. The thermocline as well as the velocity of the jet of sewage were the causes for a 2 meter deep surface override. Twice during July and August the salinity and conductivity of these waters changed from 28.0 to 31.0 g/kg and 29,000 to 32,000 $\mu\Omega$ /cm, accordingly. These alterations in water quality resulted from rapid dissolved solid input to removal and caused a weakening of correlation between summer readings of salinity, conductivity and temperature. The conductivity readings of July and August were comparable with those of the reference site, indicating a high dissolved solid content throughout their water columns.

Although Sackville Street outfall has a large volume of water and is accessible to the conditions of the Harbour, the soluble content of sewage, biochemical activity of the sludge and Harbour water movement are conditions controlling the conductivity readings. The spring thaw and storm runoff caused an increase in the size of the override field only. The water quality improvement was basically due to the frequent movement of Harbour waters into this outfall area.

Pier "A"

Monthly field averages of conductivity are presented in Table A.4.5 of Appendix A.

The conductivity readings of the sewer trunk effluent and overflow pipe ranged widely from 15,000 to 39,000 $\mu\Omega$ /cm. The dissipation of the effluents was more prevalent for the overflow pipe plume than the plume located within the Pier.

The winter conductivity readings correlated strongly with salinity and temperature and showed a uniform mixing of the water columns. The surface waters had slightly (900 $\mu\Omega$ /cm) lower conductivity readings than the bottom waters.

The winter characteristics of the water columns persisted until March. During April and May, conductivity readings indicated a continuous depletion of the water quality by showing a retention of higher dissolved solid contents in the waters of the Pier. During spring, shelf water intrusions impacted the water quality of the stations outside the Pier. The spring readings for references were incompatible with the monthly averages of the Pier waters; but similar to some of the daily values of April and May.

The dissolved solid content of the Pier increased from spring to mid-July, and decreased from July to August. During summer the surface override and activated sludge banks effected the conductivity of the water column; hence the water column had irregular readings. The reference values were similar to the values observed during July.

Containment of dissolved solids in the Pier was evident, while the waters outside this area were not effected as much. The water quality recovery was a function of the movement of Harbour waters in this area. Spring thaw and storm runoff effected the water quality of the Pier, immensely.

Summary

The conductivity in correlation with salinity, temperature and suspended solid readings provided this study with an assessment of the ionized soluble solid content of the plume waters. The capability of seawater to carry ionic charges, its depletion and replenishment, was a function of the mixing of the supernatant of sludge, resulting from biochemical activities, solids of the wastewater, volume of freshwater discharging after storms, and runoff produced

by spring thaw. In the shallow and inaccessible areas of the outfalls, the pooling of wastewater was evident. In these cases the correlation between conductance, salinity and temperature was very weak, emphasizing the containment of the suspended and dissolved particles. The susceptibility of these waters to changes was also high, but the deeper and more accessible sites showed signs of alterations. The sensitivity of the reaction to changes, the overall impact and resulted alteration was not as drastic for these sites.

The recovery of the outfall sites depended strongly on the Harbour and shelf water movement into the area which replaced the contaminated plume waters. The reference sites also contained a certain amount of soluble solids which had been transported from the outfall sites and moved northerly or southerly.

5.1.5 Analysis and Discussion of the Secchi Disc Transparency Data

The concept of the transparency measurement by the secchi disc was introduced in 1865 by the Italian Scientist, Secchi; who observed that a disk which was lowered into the water beyond a certain distance became no longer visible. Transparency reading by secchi disc is a measure of the mean depth between two points, a point where the disc disappears and a depth reading where the disc is visible again.

Traditionally, this method of measurement was used by the limnologist to estimate the level of turbidity and measure the photic zones of the lakes (Wetzel, 1983). The photic zone is the upper layer of water that receives 15 to 20% of the surface light (Baca et al, 1982). Seawater also possesses this layer and the secchi disc reading could provide a good and low cost estimate of the transparency and photic zone.

Secchi disc transparency is a function of the reflection of sunlight, this is influenced by both the absorption character of the water and the presence of dissolved and suspended matter. Therefore, the experiment should be conducted on the shaded side of the boat and better readings result when the measurements are made during mid day.

There are a number of disadvantages and limitations to the use of the secchi disc, such as wave action, reflection of the sunrays, size of the disc and human error. Transparency data, the thickness of the photic zone measured as well as the trophic state of the water column as estimated by the disc should be considered cautiously.

The factors effecting the transparency of the water are suspended and soluble solids, microorganism content, the colour of the water and surface oil and grease slicks. Impacts of low transparency reduces light penetration, this in turn decreases the rate of photosynthesis by the phytoplankton. Detrimental effects of the low photosynthesis are: low productivity of the planktons, depletion of dissolved oxygen in the water column and low rate of nutrient uptake and waste assimilation.

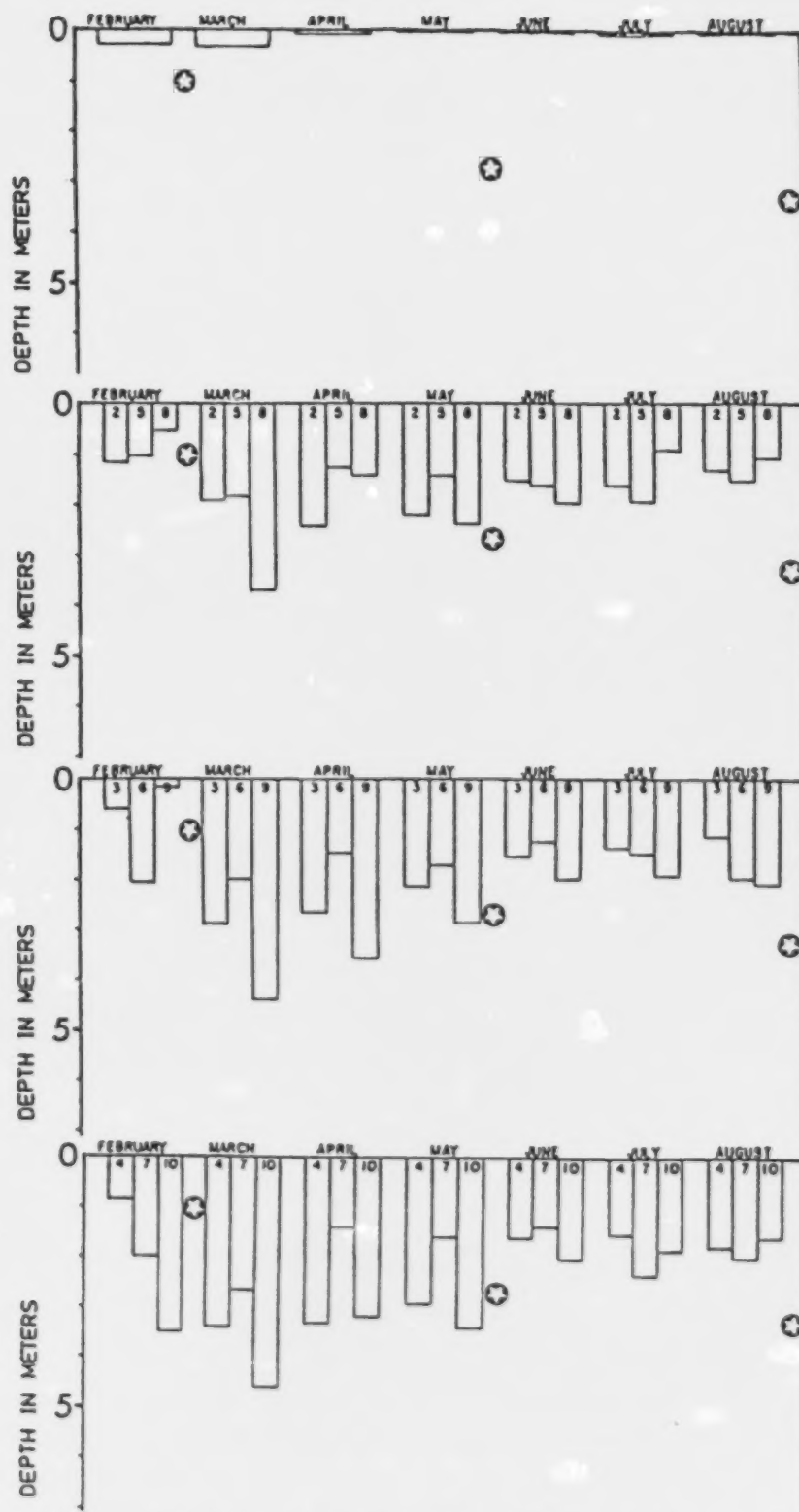
Secchi disc transparency readings of natural waters are up to 20 meters; variation of less than 20% have been recommended for the quality of the receiving seawater (U.S. standards).

Tufts Cove

Data is presented in Table A.5.1 of Appendix A and is illustrated in figure 5.38. The transparency histograms are shown in figure 5.37 for every station and references.

Secchi disc readings of the discharge point showed a very shallow photic zone of 0.0 to 60.0 cm range. February's values were similar to the transparency of the Duffus Street outfall, but in every other month the readings indicated extremely low transparency. Effluents of this outfall were regularly turbid and unusually coloured.

High transparency was observed for the 50, 100 and 150 meter stations in winter and spring. Summer secchi disc readings did not show a substantial increase in transparency of the plume waters due to dilution. The waters of stations 9 and 10 appeared to be clearer in spring. There was no clear pattern of an increase in transparency from one radial distance to the next.



5.37 MONTHLY AVERAGES OF SECCHI DISC (m) FOR THE PLUME AND STATIONS 50 m, 100 m AND 150 m AWAY FROM THE PLUME FOR TUFTS COVE, 1985. REFERENCES ARE INDICATED BY (x)

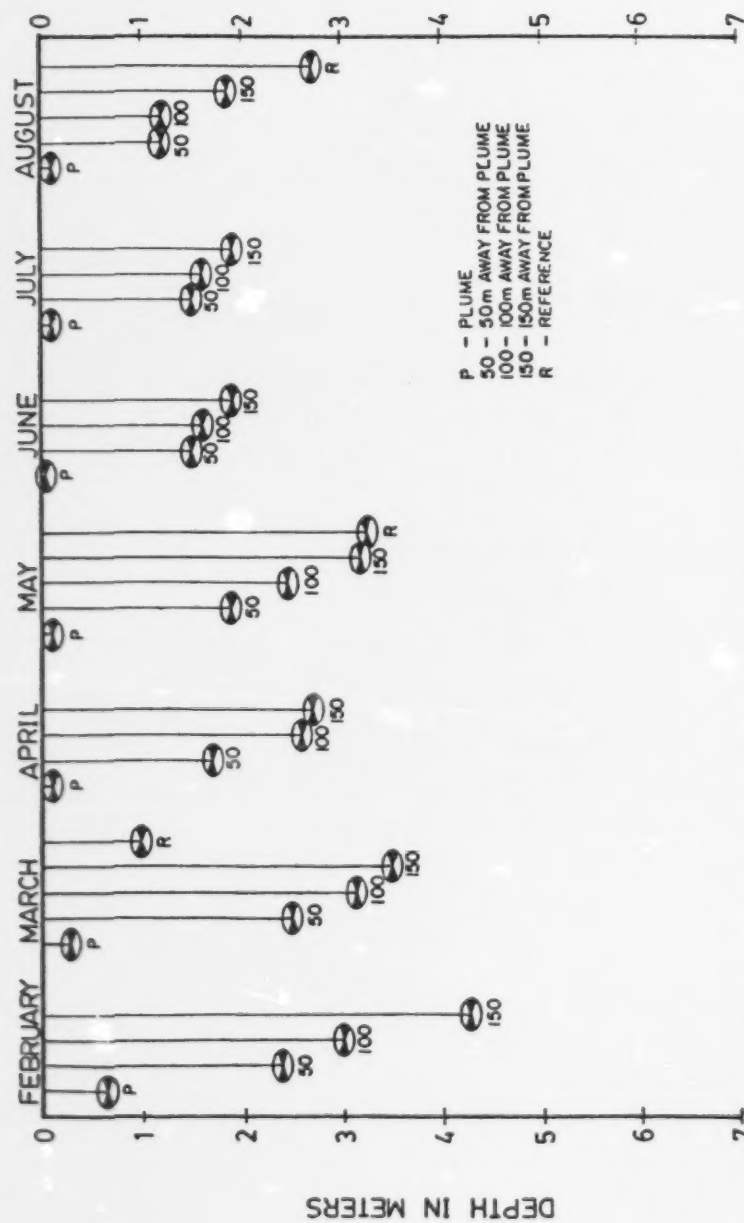


FIG. 18 MONTHLY AVERAGES OF SECCHI DISC READINGS FOR TUFTS COVE, 1985.

On occasions of apparent spills the transparency of the entirety or a great portion of the Cove water was zero. However, the average values observed over the seasons, with an exception of the point of discharge, were similar to the reference stations.

Therefore, from the analysis of the results, it was evident that the transparency values of Tufts Cove did not increase beyond 4.6 meters. However, the secchi disc readings of the cove waters (0.2 - 4.6 meters) and the reference waters (1.0 - 3.3 meters) correlated. Dilution did effect the transparency of the stations close to the entrance of the Cove, stations 8, 9 and 10 more readily than the stations closer to the point of discharge.

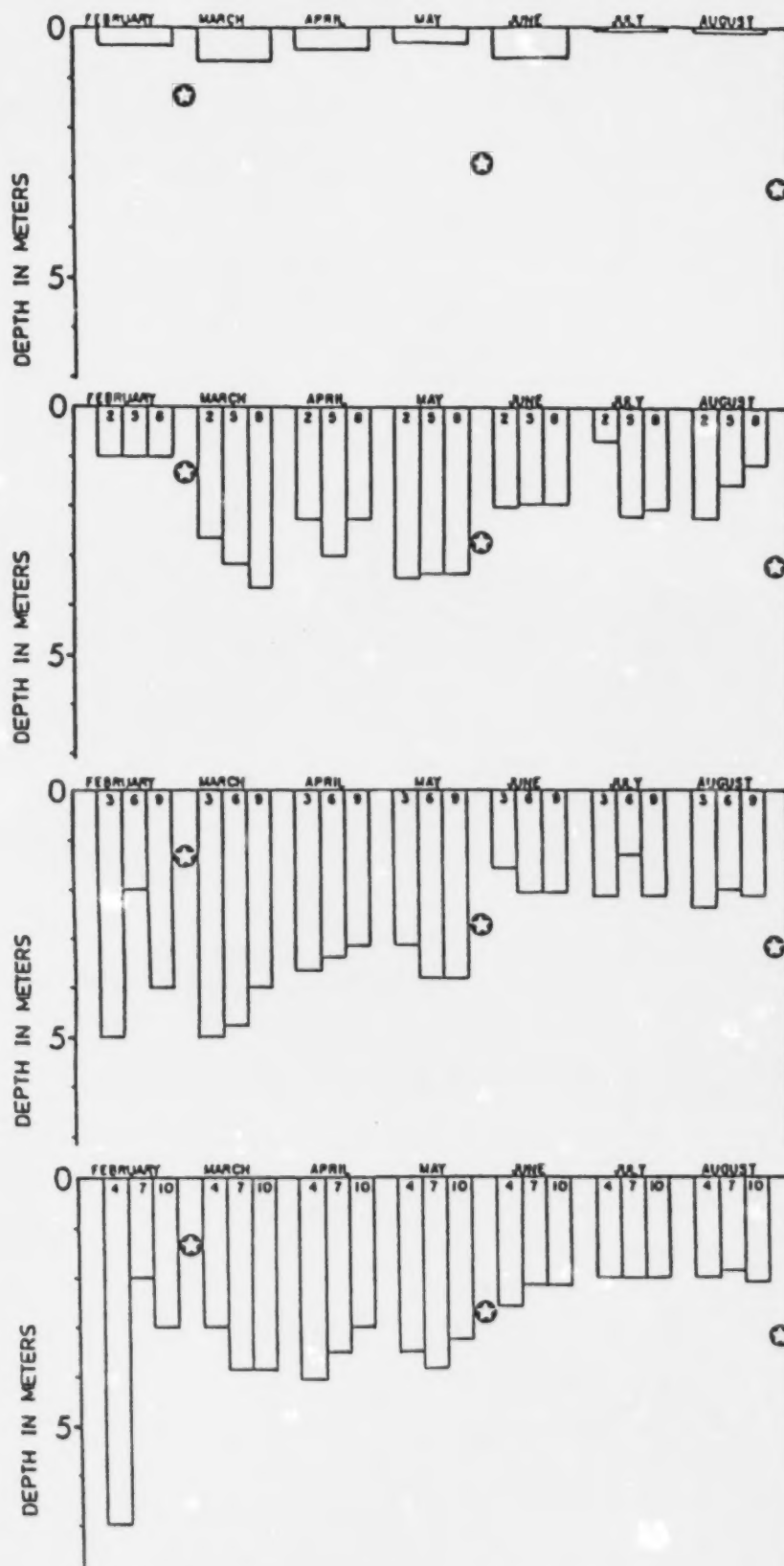
Duffus Street

Monthly averages of the secchi disc data are presented in Table A.5.2 of Appendix A. The transparency histograms and secchi disc averages are illustrated in figures and 5.39 and 5.40, respectively.

Secchi disc readings at the point of discharge at Duffus Street were in the range of 10.0 to 70.0 cm. This indicated more transparent waters at this outfall site than for Tufts Cove.

In almost every month the waters of station 4 were more transparent than the other stations (i.e. February's value) and the 150 meter stations had the highest transparency readings. This condition was due to better dilution of the plume waters at the 150 meter stations. There was an apparent increase of secchi disc readings for all the stations and references in spring, while winter and summer values were within a similar range, and lower than the stations in the middle of the Harbour.

In general, on station by station basis the waters of Tufts Cove had shallower photic zones and lower transparency values than Duffus Street. The secchi disc readings of the plume waters were similar to the reference values, but were still not within the recommended limits.



5.39 MONTHLY AVERAGES OF SECCHI DISC (m) FOR THE PLUME AND STATIONS 50 m , 100 m AND 150 m AWAY FROM THE PLUME FOR DUFFUS STREET, 1985. REFERENCES ARE INDICATED BY ⊙

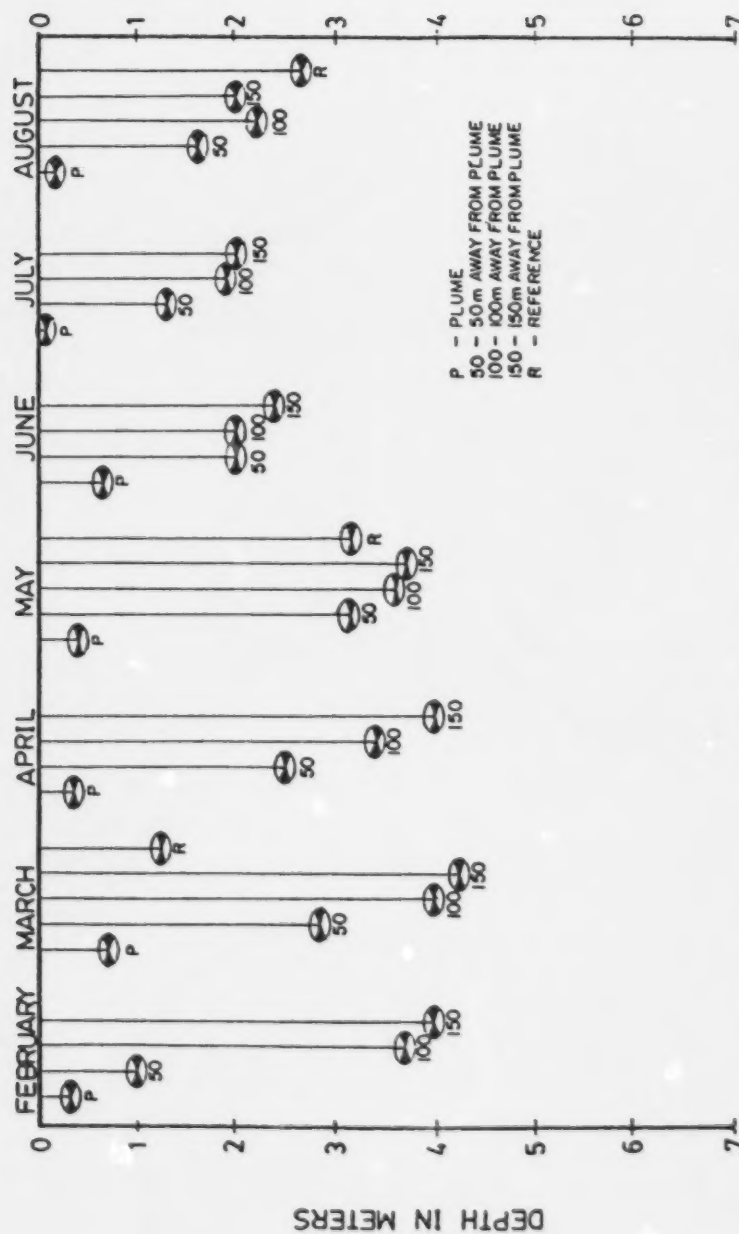


FIG.5.40 MONTHLY AVERAGES OF SECCHI DISC READINGS FOR DUFFUS STREET, 1985.

Dartmouth Cove

Monthly averages of the field data are presented in Table A.5.3 of Appendix A.

Transparency at the two discharge points did not vary greatly in range, but transparency was slightly (35%) higher in the vicinity of the Old Ferry Road discharge point.

The water column of station 10 was more transparent than any of the other stations. However, station 6, which was adjacent to the shipwrecks, had lower secchi disc readings than the other stations for every month except for April. The data indicates that there was a mixing of sewage in all the stations located in the deeper areas of the Cove.

The transparency levels of the Cove waters were lower than the reference sites during spring and in a similar range during summer. Secchi disc readings of areas of Dartmouth Cove were similar to Duffus Street outfall, and slightly lower than the other outfall sites.

Sackville Street

Monthly averages of the secchi disc readings for the Sackville Street outfall are presented in Table A.5.4 of Appendix A.

The transparency values were observed to be in a range of 10 to 70 cm at the point of discharge. There were more occasions of highly turbid waters emanating from this outfall during the summer months than any of the other months.

The furthest station from the point of discharge, station 4 did not have high transparency readings except in summer. Station 6 had clear waters in winter and spring, this was due to seaward movement of the plume waters. There were indications of an increase in transparency from station 2 to station 6 with an exception for values of station 2 that were in the same range as station 1. This indicates little mixing and dispersion between

station 1 and 2. There was a sharp increase in secchi disc readings from station 2 to 3 and to the other stations, this indicated better water circulation through the 75, 100 and 150 meter stations.

The reference stations had similar secchi disc values with the 100 and 150 meter stations. However, neither in the case of the reference stations nor the plume waters did the transparency values, return to the recommended limits.

Pier "A"

Monthly values of transparency are presented in Table A.5.5 of Appendix A.

The point of discharge at Pier "A" had secchi disc readings in the range of 0.0 to 40 cm, this was far less than all the other outfall sites usually, plume waters were highly turbid and coloured. Transparency values of the discharges from the overflow pipe showed no correlation with that of the tunnel sewer.

Stations 5 and 6, located outside the confinements of the Pier had better transparency reading than station 2 within plume 1. August secchi disc data of station 3 suggested the possibility of the movement of the plume waters towards the northeastern section of the Harbour.

Reference waters appeared to have comparable secchi disc readings as those of the plume waters. In either case the transparency values had returned to the recommended values.

In general, the waters of Halifax Harbour were not as transparent as it was recommended by the Standards of Water Quality Criteria 1972. However, the depth of the photic zone, in the outfall areas returned to a similar thickness of those observed for stations in the middle of the Harbour. Within the first 200 meters of Pier "A" transparency was always very low. The degree of recovery from the 50 meter stations onward were a function of the depth of the outfall area and its accessibility to tidal and current movements. Significant deterioration of the transparency was more readily experienced at Tufts Cove and Pier "A" than that of Dartmouth Cove, Sackville Street and Duffus Street.

5.1.6 Analysis and Discussion of the Chemical Oxygen Demand Data

Chemical Oxygen Demand (COD) is a measure of the oxygen requirement in relation to the total quantity of chemical contaminants in sanitary and industrial sewage. This detection technique is based on the fact that all the organic compounds of wastewater, with the exception of aromatic hydrocarbons and pyridine, can be oxidized by a strong acid. The organic matter is converted to carbon dioxide and water regardless of the measure of biological assimilability of the compound, thus the COD readings are always greater than the BOD values.

The major limitations of the COD test are: the incapability of the experiment to differentiate between biologically oxidizable and biologically inert organic compounds and the procedure does not provide a measure of the rate of biological activity needed to stabilize the chemical. The advantage of the test is that the acidic reagent under high temperature digests the COD materials in colloidal and particulate form.

Chemical and biochemical oxygen demand results can not be expected to have a good correlation since these tests assess different aspects of the degradable contaminants of wastewater. This correlation might be established after careful consideration of a large data set. The correlation between the BOD and COD of the sewage-seawater of Halifax Harbour was non-existent, since there were a great number of interfering conditions prevailing in this environment with diverse quality of discharges.

Although COD has not been recognized as a standard test for assessment of contaminants; it provides a better measure than the BOD₅ test of wastewater from mixed domestic and industrial origin. The COD test is superior because there is complete digestion of most organics rather than only the biodegradable compounds and the high ($\pm 20\%$) BOD₅ error margin, especially since the standard BOD samples were not diluted with seawater.

There are no cited standards for COD levels in the effluents. Raw domestic sewage contains an average of 270 mg/L of COD; while the industries in Halifax and Dartmouth such as the breweries have a concentration of

refinery wastes contain 1000 mg/L of COD. The content of septic tanks have up to 15,000 mg/L of COD. The quality of chemical discharges from garages, institutions and industrial outlets of Burnside is not known.

Tufts Cove

Monthly averages of COD values as well as the statistical analysis of the daily data are presented in Table B.1.1 of Appendix B. Corresponding graphs are illustrated in figures 5.41 to 5.44.

Chemical Oxygen Demand of the manhole effluents were in the range of 48.3 to 363.3 mg/L. At the point of discharge the COD readings were in the range of 231.0 to 780.7 mg/L, which resulted in a contaminant accumulation of up to 570% and reduction due to dilution of 36% (refer to Table 5-16). This fact emphasizes the industrial and septic tank effluent discharges to this area (septic tank average COD loading is around 15,000 mg/L. A short delay in sampling time of the manhole and the point of discharge could be a hindrance in evaluating the percent reduction due to dilution. An analytical assessment of the COD values of the sampling stations showed that the delay in sampling time was only significant in assessing the initial dilution, since there was a slow rate of COD assimilation or removal occurring throughout the Cove.

Surface waters showed a percent reduction of 12.0 to 76.0% while the bottom waters had 10.2 to 74.5% decrease in COD content (Table 5-1). The COD values of the water columns indicated vertical mixing but the distribution pattern was very erratic between stations. This indicated a sporadic removal or assimilation.

Chemical oxygen demand values of May and July were higher than the other months and the August values were the lowest which indicated seasonal dependency. However, the COD testing was not conducted long enough to be conclusive as to whether or not the peak values were seasonally dependent. The minimum and maximum station values observed were 4.6 to 1,321.5 mg/L of COD, with small correlations with contaminant concentration at the discharge point.

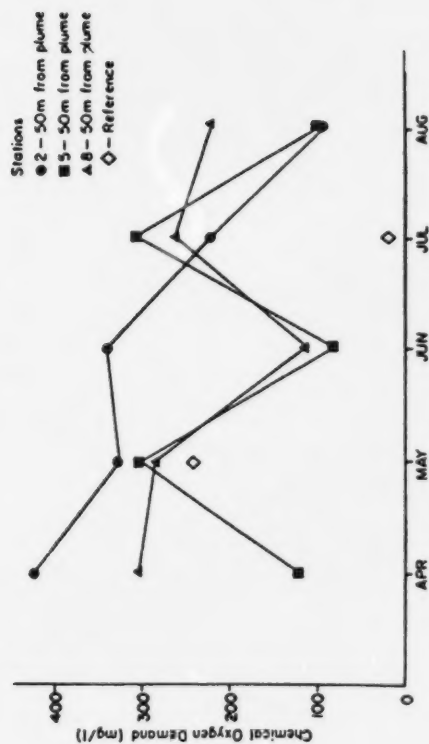


FIGURE 5.62A MONTHLY AVERAGES OF CHEMICAL OXYGEN DEMAND FOR THE SURFACE STATIONS, 50 m FROM THE PLUME AT TUFTS COVE.

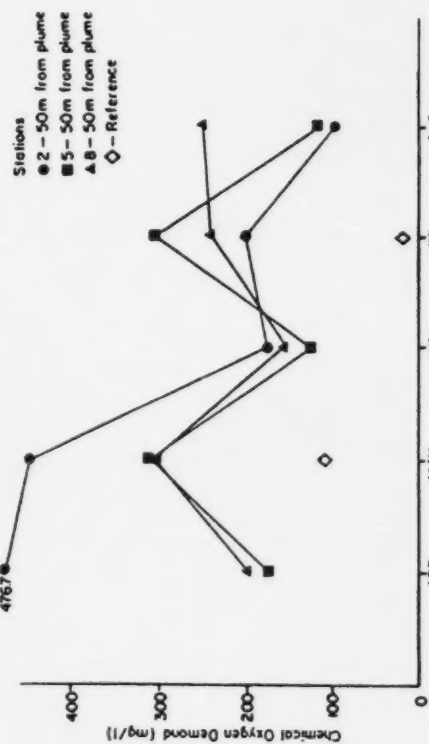


FIGURE 5.62B MONTHLY AVERAGES OF CHEMICAL OXYGEN DEMAND FOR THE DEPTH STATIONS, 50 m FROM THE PLUME AT TUFTS COVE.

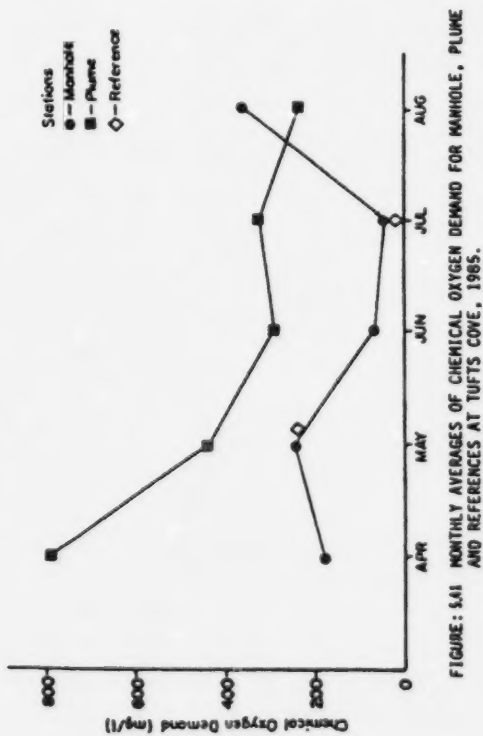


FIGURE 5.61 MONTHLY AVERAGES OF CHEMICAL OXYGEN DEMAND FOR MANHOLE, PLUME AND REFERENCES AT TUFTS COVE, 1985.

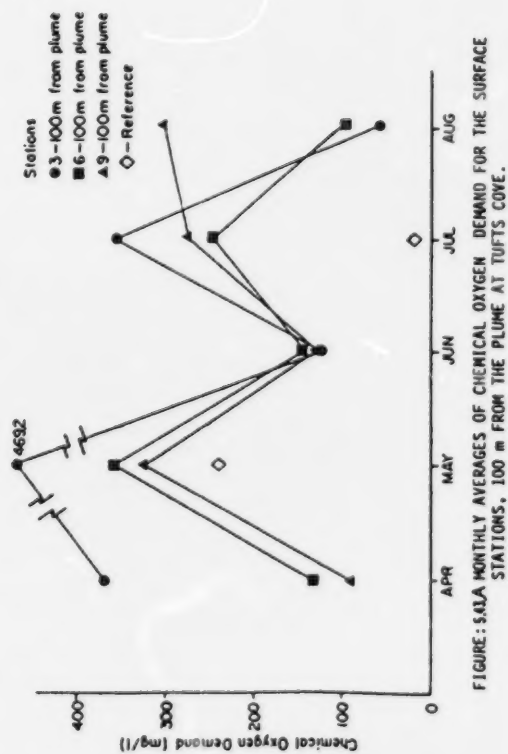


FIGURE: SA3A MONTHLY AVERAGES OF CHEMICAL OXYGEN DEMAND FOR THE SURFACE STATIONS, 100 m FROM THE PLUME AT TUFTS COVE.

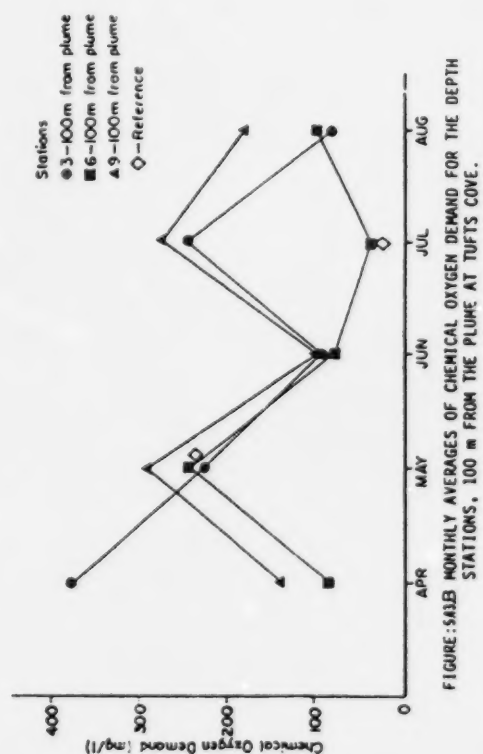


FIGURE: SA3B MONTHLY AVERAGES OF CHEMICAL OXYGEN DEMAND FOR THE DEPTH STATIONS, 100 m FROM THE PLUME AT TUFTS COVE.

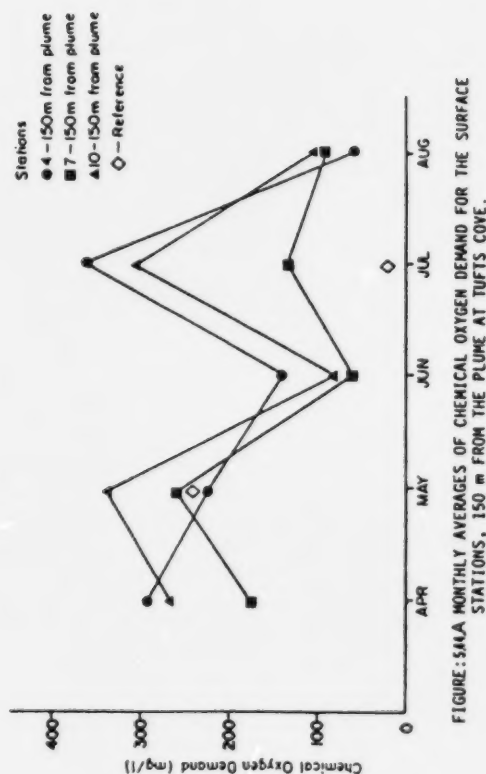


FIGURE: SA4A MONTHLY AVERAGES OF CHEMICAL OXYGEN DEMAND FOR THE SURFACE STATIONS, 150 m FROM THE PLUME AT TUFTS COVE.

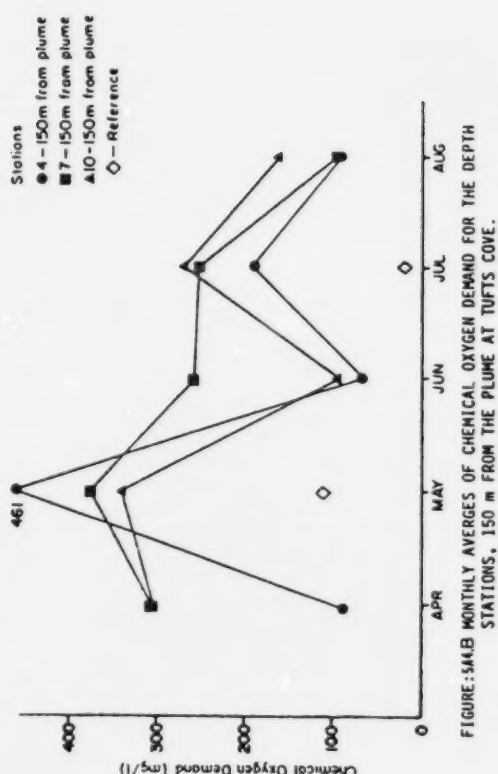


FIGURE: SA4B MONTHLY AVERAGES OF CHEMICAL OXYGEN DEMAND FOR THE DEPTH STATIONS, 150 m FROM THE PLUME AT TUFTS COVE.

Table 5-1 Percent reduction of Chemical Oxygen Demand in comparison with the discharge point or the manhole at Tufts Cove outfall, due to dispersion, assimilation and removal by tides and currents.

Month	Source Strength	% reduction from the source at the 50 meter stations	% reduction between the 50 and the 100 meter stations	% reduction from the source at the 100 meter stations	% reduction between the 100 and 150 meter stations	% reduction from the source at the 150 meter stations
April 1985	780.7*	63.7 S 63.6 B	11.0 S 10.9 B	74.7 S 74.5 B	-6.0 S -4.5 B	68.7 S 70.0 B
May	437.8*	30.6 S 20.4 B	-18.2 S 21.8 B	12.4 S 42.2 B	24.9 S -30.0 B	37.3 S 10.2 B
June	294.5*	39.5 S 44.2 B	16.5 S 25.7 B	56.0 S 69.9 B	11.8 S -17.5 B	67.8 S 52.4 B
July	327.0*	19.3 S 18.2 B	-2.7 S 0.1 B	16.6 S 18.3 B	8.7 S -23.2 B	25.3 S 27.4 B
August	363.3	62.1 S 57.0 B	-3.9 S 9.9 B	58.0 S 66.9 B	18.8 S -23.2 B	76.8 S 43.7 B

* Plume
S = Surface
B = Bottom
- = assimilation

Although, it was expected that the COD concentration due to dilution, removal or assimilation would decrease with distance from the point of discharge, the 100 and 150 meter stations had similar or higher concentrations of the contaminant. This clearly showed a lack of any removal or assimilation of the pollutant from the plume waters; and indicated the additive effect of this contaminant in the Cove.

Spring COD reference values were lower than the plume waters' with an exception for May. Summer reference values showed a drop from those of spring; and the plume waters had substantially higher COD loadings than those of the reference sites. In comparison with the "5 day COD" values reported by N.S.D.O.E. 1976, the manhole samples had lower COD content; but the values at the point of discharge were comparable.

Duffus Street

Monthly averages and statistical analysis of daily data are illustrated in Table B.1.2 of Appendix B. The related graphs are presented in figures 5.46 to 5.49.

COD content of the manhole samples ranged from 105.9 to 294.0 mg/L; while the point of discharge had a range of 94.0 to 254.0 mg/L, which resulted in an accumulation 60% and a percent reduction 58% (Table 5-16). The dilution rate was higher than the range observed at Tufts Cove. During 3 out of 5 months of analysis the contaminant accumulated at the point of discharge.

Although this outfall services a larger and more diverse tributary area, average COD loadings in the plume area of Duffus Street were substantially lower than Tufts Cove. The minimum and maximum COD values observed were 4.6 and 727.0 mg/L and both occurred in July indicating seasonal dependency.

In general, the COD concentration in the plume waters of Duffus Street had the highest accumulation during the summer months. For instance, COD values of June showed accumulation in the vicinity of Halifax Industries, while the dilution and removal took place in stations 2, 3 and 4. An addition and

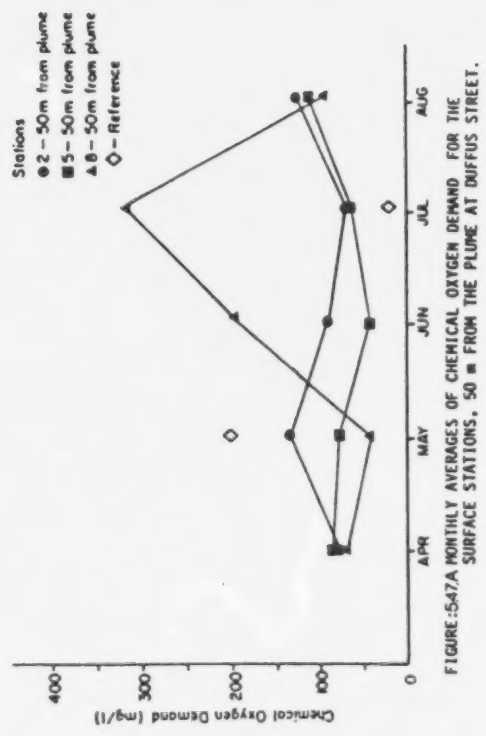


FIGURE:547A MONTHLY AVERAGES OF CHEMICAL OXYGEN DEMAND FOR THE SURFACE STATIONS, 50 m FROM THE PLUME AT DUFFUS STREET.

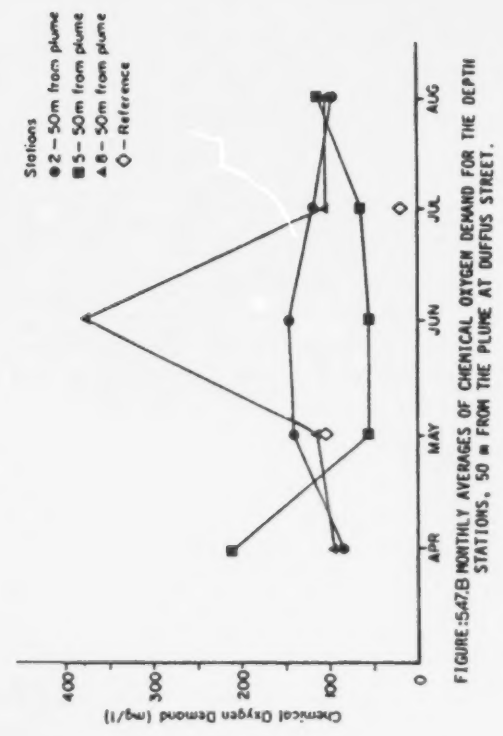


FIGURE:547B MONTHLY AVERAGES OF CHEMICAL OXYGEN DEMAND FOR THE DEPTH STATIONS, 50 m FROM THE PLUME AT DUFFUS STREET.



FIGURE: 546 MONTHLY AVERAGES OF CHEMICAL OXYGEN DEMAND FOR MANHOLE, PLUME AND REFERENCES AT DUFFUS STREET, 1985.

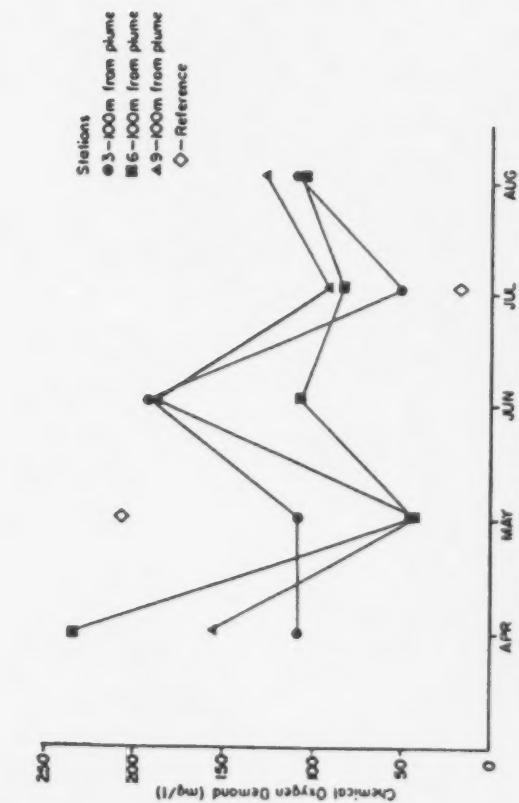


FIGURE: S48A MONTHLY AVERAGES OF CHEMICAL OXYGEN DEMAND FOR THE SURFACE STATIONS, 100 m FROM THE PLUME AT DUFFUS STREET.

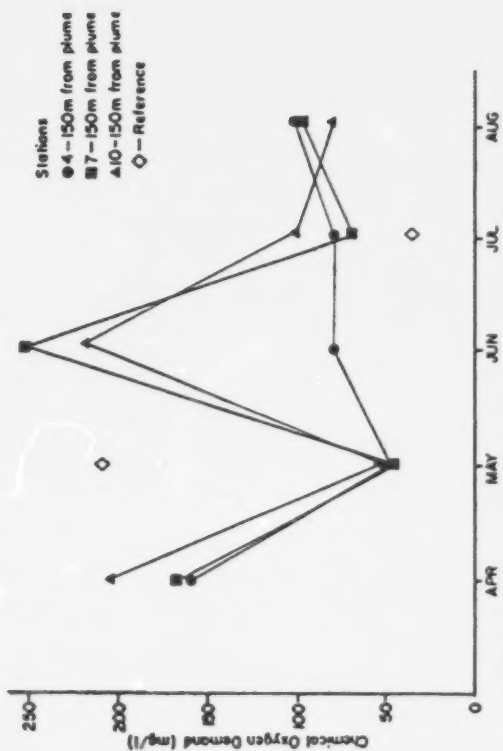


FIGURE: S48A MONTHLY AVERAGES OF CHEMICAL OXYGEN DEMAND FOR THE SURFACE STATIONS, 150 m FROM THE PLUME AT DUFFUS STREET.

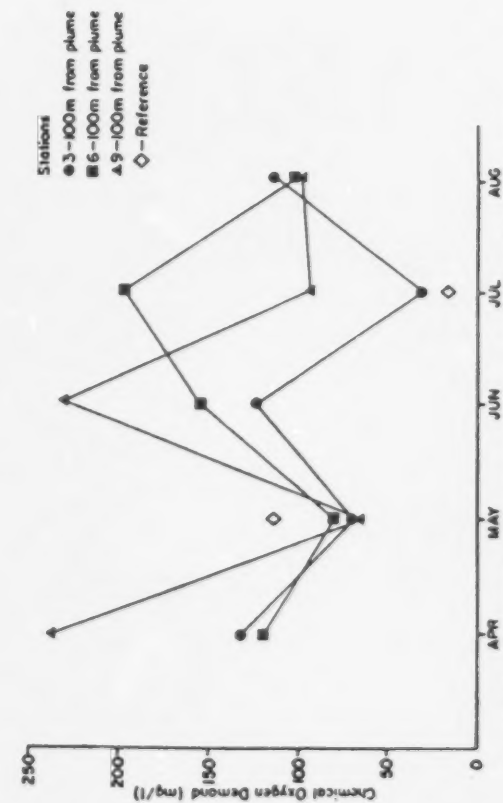


FIGURE: S48B MONTHLY AVERAGES OF CHEMICAL OXYGEN DEMAND FOR THE DEPTH STATIONS, 100 m FROM THE PLUME AT DUFFUS STREET.

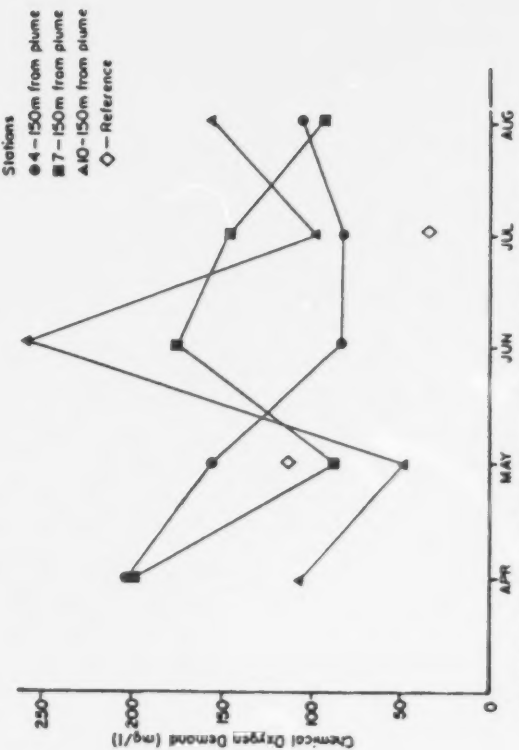


FIGURE: S48B MONTHLY AVERAGES OF CHEMICAL OXYGEN DEMAND FOR THE DEPTH STATIONS, 150 m FROM THE PLUME AT DUFFUS STREET.

Table S-2 Percent reduction of Chemical Oxygen Demand in comparison with the discharge point or the manhole at Duffus Street outfall, due to dispersion, assimilation and removal by tides and currents.

Month	Source Strength	% reduction from the source at the 50 meter stations	% reduction between the 50 and the 100 meter stations	% reduction from the source at the 100 meter stations	% reduction between the 100 and 150 meter stations	% reduction from the source at the 150 meter stations
April 1985	114.3*	33.6 S 11.4 B	-75.8 S -35.0 B	42.2 S 46.4 B	-46.8 S -4.2 B	59.0 S 50.6 B
May	185.5*	55.3 S 43.7 B	8.3 S 17.3 B	63.6 S 60.9 B	9.9 S 13.4 B	73.5 S 47.5 B
June	109.2	30.1 S 76.5 B	0.4 S 19.3 B	29.7 S 57.2 B	24.3 S -1.5 B	54.0 S 58.7 B
July	254.0*	57.5 S 62.1 B	12.9 S -4.8 B	70.4 S 57.3 B	3.4 S -0.6 B	67.0 S 56.8 B
August	294.0	62.3 S 64.8 B	-1.9 S -1.3 B	60.4 S 63.5 B	0.1 S -3.5 B	60.5 S 60.0 B

* Plume
S = Surface
B = Bottom
- = assimilation

removal percentage of -59% to 73.5% for surface and -76% to 64.8% for the bottom stations was encountered. Consideration should be given to comparative concentrations of the contaminant at the point of discharge and at each station (Table 5-2).

The surface stations at Duffus Street outfall had higher COD concentrations during April and May, and were vertically mixed in the other months. Neither a pooling effect of the contaminant in station 2 nor a higher dilution rate at station 4 was observed, as for all the other parameters.

Duffus Street plume waters had a higher COD content than the reference sites in the summer and comparable values in spring. COD₅ manhole sample values range observed by N.S.D.O.E. 1976 (258.0 to 618.0 mg/L) were substantially higher than the COD values reported here.

Dartmouth Cove

Monthly averages for chemical oxygen demand and the analysis of the daily data are presented in Table B.1.3 of Appendix B.

Chemical oxygen demand values at the point of discharge were in the range of 107.6 to 268.5 mg/L and the manhole ranged from 96.0 to 533.0 mg/L, which resulted in a addition of 180% and reduction of 80% of chemicals due to dilution (Table 5-16). Old Ferry Road discharged 59.9 to 148 mg/L of COD. This was substantially lower than that of Maitland Avenue sewage output. It is important to note that only in April was there an accumulation of COD in Dartmouth Cove. The initial loading into the Cove was larger than the Duffus Street outfall.

In the 150 meter plume waters there was a 40.3 to 85.01% reduction of COD (Table 5-3) in the surface waters and 51.8 to 86.5% reduction in the bottom stations. This indicated little vertical mixing had taken place in the water column, but there was a certain amount of dilution or removal throughout the plume waters from the points of discharge.

Based on analysis of the daily data, minimum and maximum observed values in the Cove were 2.9 to 871.2 mg/L of COD. In comparison, there were more

Table 5-3 Percent reduction of Chemical Oxygen Demand in comparison with the discharge point or the manhole at Dartmouth Cove outfall, due to dispersion, assimilation and removal by tides and currents.

Month	Source Strength	% reduction from the source at the 50 meter stations	% reduction between the 50 and the 100 meter stations	% reduction from the source at the 100 meter stations	% reduction between the 100 and 150 meter stations	% reduction from the source at the 150 meter stations
April 1985	416.0*	51.4 S 69.4 B	16.5 S -0.4 B	67.9 S 69.0 B	4.9 S 15.0 B	72.8 S 84.0 B
May	533.0	86.5 S 86.8 B	-6.5 S 0.7 B	80.0 S 87.5 B	7.1 S -4.4 B	87.1 S 83.1 B
June	272.0	59.4 S 69.2 B	-5.4 S -20.4 B	54.0 S 48.3 B	9.7 S 15.7 B	63.7 S 64.0 B
July	256.6*	50.3 S 58.8 B	2.4 S 5.5 B	52.7 S 64.3 B	-3.5 S 8.4 B	99.2 S 72.7 B
August	255.6*	53.3. S 52.9 B	5.6 S 2.2 B	58.9 S 55.1 B	-3.5 S 0.7 B	55.4 S 55.8 B

* Plume 1 plus Plume 2

S = Surface

B = Bottom

- = assimilation

contaminants retained in the Cove during summer. According to estimates of COD for the reference sites, the spring concentrations in the plume waters were lower while the summer values of the Cove were substantially higher than the loading in the middle of the Harbour. N.S.D.O.E. 1976 reported values of 16.0 to 115.0 mg/L of COD for the manhole of Maitland Avenue which was lower than the values reported here.

Sackville Street

Monthly averages of COD for Sackville Street and the relevant statistical analysis of the daily data are presented in Table B.1.4 of Appendix B.

An initial range concentration of 216.5 to 523.6 mg/L of COD in the manhole samples and a range of 102.8 to 197.8 mg/L for the point of discharge yielded a percent reduction of 30.0 to 62.0% (Table 5-16). The COD values emanating from this discharge point were higher than that of Dartmouth Cove and Duffus Street outfalls.

There was 3.6 to 71.7% dilution and removal present for the surface waters and 26.1 to 62.5% for the bottom waters of the plume area (Table 5-4). These percentages showed vertical mixing within the water column as well as relatively active removal in progress. There was no evidence of seasonal dependency in the removal pattern.

A range of 8.3 to 869.0 mg/L of COD was encountered in the plume waters of Sackville Street which was the second largest range observed after Tufts Cove. This emphasized a relatively high amount of chemicals being discharged from the Sackville Street area. In comparison, COD values in the outfall area were seldom lower than the reference sites, otherwise during every other month the COD values of the Sackville Street plume waters were higher than the references.

Pier "A"

Monthly averages and respective daily statistical analysis are illustrated in Table B.1.5 of Appendix B.

Table 5-4 Percent reduction of Chemical Oxygen Demand in comparison with the discharge point or the manhole at Sackville Street outfall, due to dispersion, assimilation and removal by tides and currents.

Month	Source Strength	% reduction from the source at the 50 meter stations	% reduction between the 50 meter and the 100 meter stations	% reduction from the source at the 100 meter stations	% reduction between the 100 and 150 meter stations	% reduction from the source at the 150 meter stations
April 1985	523.6	71.7 S 48.2 B	-22.2 S 14.9 B	49.5 S 54.2 B	-1.3 S 8.3 B	48.2 S 62.5 B
May	148.8 ^a	44.0 S 43.3 B	-1.0 S -1.1 B	43.0 S 41.8 S	0.3 S -1.6 B	43.3 S 40.2 B
June	410.4	69.2 S 62.1 B	-13.1 S -27.1 B	56.1 S 50.8 B	6.0 S 6.3 B	62.1 S 57.1 B
July	216.5	3.6 S 30.9 B	40.0 S 25.3 B	43.6 S 51.4 B	-12.7 S -13.5 B	30.9 S 37.9 B
August	217.5	4.0 S 31.3 B	39.8 S 25.2 B	43.8 S 51.6 B	-12.5 S -13.4 B	31.3 S 38.2 B

^a Plume
S = Surface
B = Bottom
- = assimilation

Manhole COD values were in the range of 125.0 to 682.6 mg/L, while the discharge points chemical concentration were 111.0 to 200.5 mg/L. Thus, there was a 0.0 to 74.0% reduction due to dilution present at the discharge point. Discharges of the sewer overflow pipe had a lesser COD content of 97.5 to 232.7 mg/L (Table 5-16).

There was an evident vertical mixing of the plume waters at both discharge points. A COD reduction of 11.6% to 89.2% occurred in the surface waters and a 3.1% to 89.2% of bottom waters (Tables 5-5A & B). The calculation procedure in this case was done in relation to both discharge points. The observed concentration of COD and reductions were subjected to daily and monthly variations more readily than seasonal. Both minimum and maximum values of 7.2 to 589.6 mg/L were present in June indicating seasonal independence.

Manhole values observed by N.S.D.O.E. 1976 report were lower than these values presented here. In all seasons, the COD concentrations were lower than the reference stations.

Summary

During the monitoring period a significant chemical oxygen demand accumulation was evident around the sewer outfall areas as well as throughout the Harbour. Even though summer COD values of the references were substantially lower, they were comparatively similar to the August values observed in the vicinity of the outfalls. Furthermore, the BOD values for the summer months increased from those of spring. These facts emphasize that the biological assimilation was occurring in spring while removal of chemical contaminants was predominantly a function of the summer tidal and current activities.

The COD data showed a certain amount of dilution, removal and possible oxidation from the outfall sites to the reference stations. However, a certain amount of chemical contaminants were being deposited in the Basin and/or discharged to the outer Harbour areas. The quantity of the contaminants displacement has to be further studied, since sampling the Harbour twice was not enough in deciding the rate and quantity of chemical removal from the Inlet waters.

Table 5-5A Percent reduction of Chemical Oxygen Demand in comparison with the discharge point or the manhole at Pier "A" outfall, due to dispersion, assimilation and removal by tides and currents (plume 1).

Month	Source Strength	% reduction from the source at the 200 meter stations	% reduction between the 200 and the 400 meter stations	% reduction from the source at the 400 meter stations	% reduction between the 400 and 450 meter stations	Source Strength	% reduction from the source at the 450 meter stations
April 1985	682.6	89.9 S 86.3 B	1.1 S 11.8 B	88.8 S 74.5 B	28.9 S 1.7 B	174.2 S 271.6 B	59.9 S 72.8 B
May	200.5*	15.5 S 9.5 B	3.3 S 6.4 B	12.2 S 3.1 B	47.1 S 64.3 B	398.8 S 417.1 B	59.3 S 67.4 B
June	385.6	78.5 S 82.9 B	-1.8 S 7.8 B	80.3 S 75.1 B	48.8 S 25.0 B	228.0 S 248.3 B	31.2 S 50.1 B
July	275.0	72.8 S 59.9 B	5.0 S 0.7 B	67.8 S 59.2 B	0.7 S -9.4 B	321.3 S 344.8 B	67.1 S 68.6 B
August	125.0	25.6 S 24.5 B	-27.4 S -22.9 B	53.0 S 47.4 B	-12.8 S -13.8 B	173.8 S 180.8 B	65.8 S 61.2 B

* Plume
S = Surface
B = Bottom
- = assimilation

Table 5-5B Percent reduction of Chemical Oxygen Demand in comparison with the discharge point at Pier "A" outfall, due to dispersion, assimilation and removal by tides and currents (plume 2).

Month	Source Strength	% reduction from the source at the 200 meter stations	% reduction between the 200 and the 400 meter stations	% reduction from the source at the 400 meter stations	% reduction between the 400 and 450 meter stations	% reduction from the source at the 450 meter stations
April 1985	97.5	28.4 S 24.1 B	-58.7 S -64.0 B	87.1 S 88.0 B		
May	222.8	27.2 S 39.0 B	10.2 S 36.0 B	17.0 S 3.0 B		
June	152.2	3.0 S 18.6 B	-87.0 S 8.4 B	90.0 S 10.2 B		
July	232.7	54.5 S 53.5 B	-15.5 S -23.3 B	70.0 S 76.8 B		
August	115.0	93.0 S 38.9 B	54.6 S 20.9 B	38.4 S 18.0 B		

S = Surface
B = Bottom
- = assimilation

The great quantity of chemical discharges at Tufts Cove, Pier "A", and Duffus Street were not the only causes for concern. Others include the chemical contribution of leachates from the dumps at Fairview Cove and Lyle Street, the discharges from the Halifax, Dartmouth Dockyards and Department of National Defence establishments as well as refineries, breweries and smaller industries.

The biologically inert organic compounds discharged from these sources can be pooled within the Harbour for periods up to 2 to 3 days and in the Basin up to 5 days. Considering the loadings from industrial sources, the containment of the chemicals in the water column could have detrimental effects on the biota. Possible transport of these chemicals to Eastern Passage, at the mouth of the Harbour and the impact of population and industrial growth, needs special consideration. Further consideration of the chemical contaminants of the Inlet system would prove useful.

5.1.7 Analysis and Discussion of the Biochemical Oxygen Demand Data

Biochemical Oxygen Demand (BOD) of sanitary sewage and industrial effluent is the measure of the oxygen molecules required to stabilize the biodegradable chemicals available in a water column. As a result of this "Aerobic Biochemical" reaction, there is a continuous depletion of available oxygen in the water column. Oxygen demand required by three classes of chemicals are measured by BOD tests, these compounds are: carbonaceous materials, oxidizable nitrogenous compounds and some of the reducing chemical compounds. The origin and the type of waste are the deciding factors in the level and rate of waste decomposition.

The empirical measurement of the oxygen demand, BOD test, is a series of wet oxidation reactions in which the living organisms (mainly bacteria), act as the stabilizing force. Two major factors are significant in the efficiency rate of the phenomenon and the test: 1). the nature as well as the availability of the compounds and 2). the population of the microorganisms plus their conditional requirements.

Obviously, biodegradable compounds in sanitary and industrial sewage are very different. Thus, the portion of the compound present in the solution are more readily available than the parts which occur in colloidal and coarse form; which has to undergo hydrolytic action for reactivation of bacteria. Industrial and domestic sewage containing complex substances such as lignin and some synthetic detergents such as nitrilotriacetic acid have slower decomposition rates and the stabilization reaction are more complex. The velocity of the wastewater through the sewer pipes and at the point of discharge effects the particle size and decomposition rate of the biodegradable compounds (i.e. Sackville Street compared to Pier "A"). However, the "clumping action" of the waste particles at the point of discharge, as it was observed by Humphrey et al 1983, causes a delay and decreases the decomposition rate substantially. This is a prevailing mechanism at the discharge points in Halifax Harbour.

The wastewater originating from a tributary area with mixed land use activities, such as Halifax and Dartmouth, have a 30-40% organic content. Thomann, 1979, estimates an oxygen demand of 400 mg/L in municipal waste of which 20 mg/L of this total is organic nitrogen. Dustan et al 1982, argue that nitrogen rather than phosphorus is the limiting nutrient of marine phytoplankton. Considering all the above facts the nitrogenous compounds of sewage-seawater is of significance. The presence of a significant density of nitrifying bacteria in the estuarine waters interferes substantially with an accurate measurement of carbonaceous BOD in seawater. Thus, it is documented that BOD levels detected in the marine water sample is hindered by nitrifying bacteria, so the actual oxygen demand values should be higher. Measurement of the BOD content of these plume waters are also made more complicated because of an overabundance of phytoplanktons of marine waters. In the case of this study, the dilution water used was not saline water, this inhibits the activity of sea-origin bacteria for a short period of time. As a result, the BOD readings are lower than the actual values (Rosenthal 1986). Therefore, it is important to note that the BOD values documented in this report, and other studies not taking the above facts into consideration, could be one half to one fifth of the actual BOD values (Rosenthal, Personnel Communications).

Federal Department of the Inland waters recognizes the plume water as the limited use zone (LUZ) and does not provide a standard for these waters. The

guidelines for effluent and wastewater quality (EPS-1-EC-76-1) recommends a maximum discharge of 20 mg/L of BOD₅ from treatment units. Other relevant standards indicate a BOD₅ of 5 to 10 mg/L for bathing and 10 to 30 mg/l for fishing and wild life propagation.

Tufts Cove

Monthly averages and statistical analysis of the daily data are illustrated in Table B.2.1 of Appendix B.

Review of the data and figures 5.45, 5.50 to 5.55 indicate a range of 11.0 to 150.0 mg/L of BOD in the manhole samples and 12.8 to 122.0 mg/L in the samples from the discharge point. A comparison between these two ranges has shown a 2.0 to 75.0% reduction due to initial dilution (Table 5-16).

There was a marked drop in the BOD concentrations from the point of discharge to the 150 meter stations. In almost every month the 50 meter stations had higher surface BOD values, indicating the override of wastewater. This condition was dependent on the season, which decided the extent of the field of dispersion.

Generally, the BOD concentrations were less in spring and summer months due to presence of warmer waters and less during the winter months. The maximum and minimum observed daily values were proof of this fact. According to the BOD data, a certain amount of dilution and disperison was occurring in the Cove (Table 5-6).

In comparison to the reference stations, the BOD readings of the Cove were slightly higher, but comparable. The summer BOD values for the references were higher than those observed in the Cove, this might have resulted from the transfer of organics from other sources and the presence of warm waters. Within 150 meters of the plume area BOD concentrations return to the recommended values of 5.0 to 10.0 mg/L for fishing and swimming. The manhole BOD averages reported by this report were lower that observed by N.S.D.O.E, 1976.

The mechanisms of removal or assimilation of BOD in Tufts Cove were

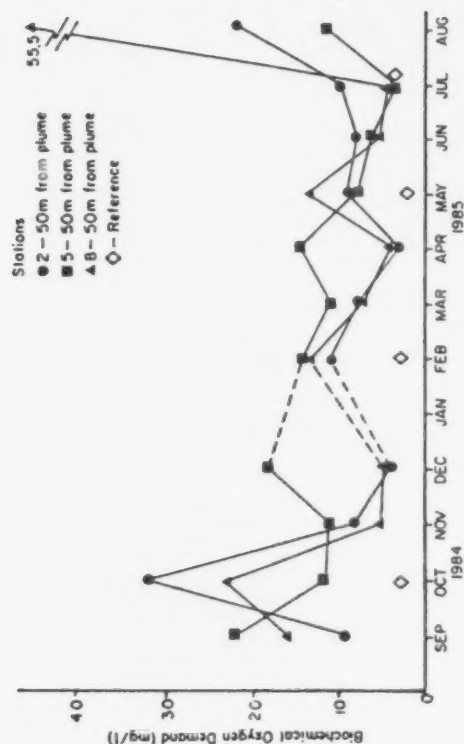


FIGURE: 550 MONTHLY AVERAGES OF BIOCHEMICAL OXYGEN DEMAND FOR THE SURFACE STATIONS, 50 m FROM THE PLUME AT TUFTS COVE.

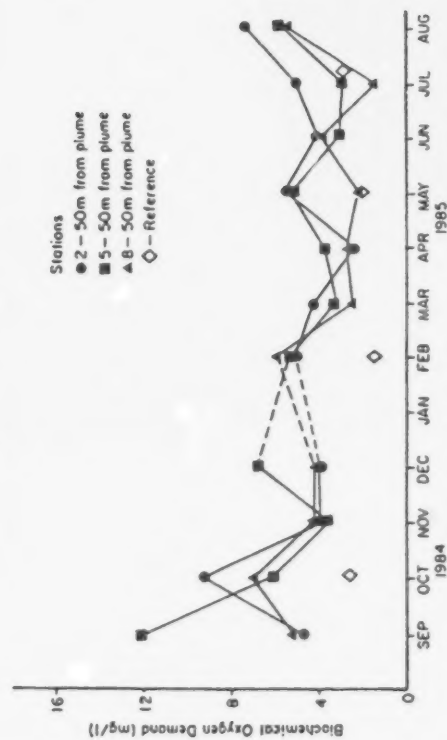


FIGURE: 551 MONTHLY AVERAGES OF BIOCHEMICAL OXYGEN DEMAND FOR THE DEPTH STATIONS, 50 m FROM THE PLUME AT TUFTS COVE.

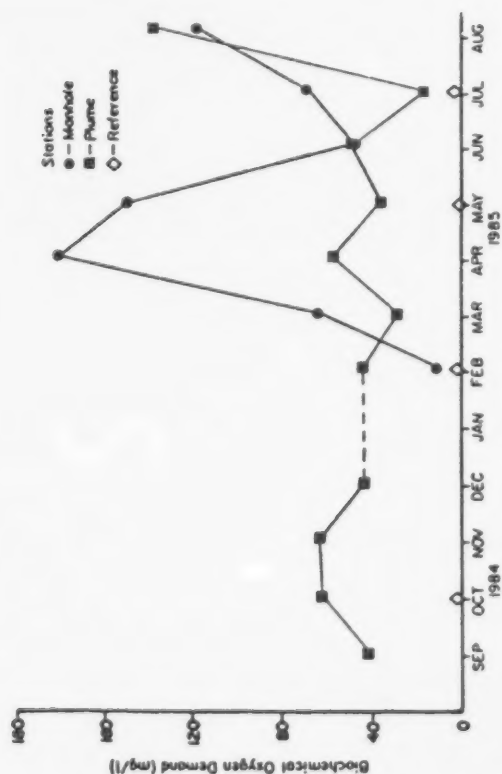


FIGURE: 545 MONTHLY AVERAGES OF BIOCHEMICAL OXYGEN DEMAND FOR MANHOLE, PLUME AND REFERENCES AT TUFTS COVE, 1985.

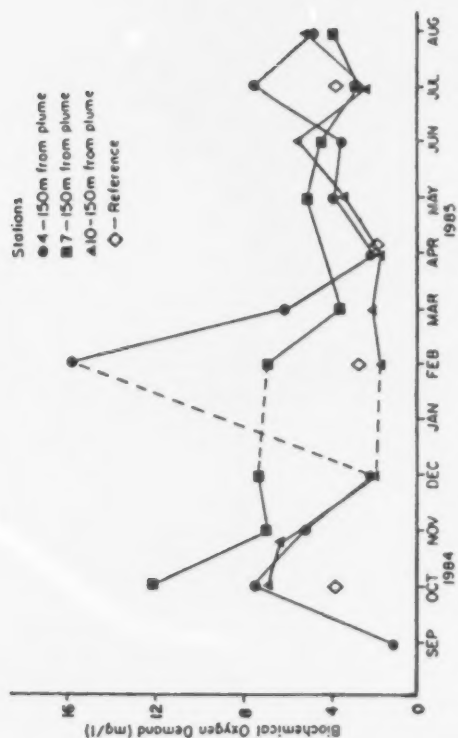


FIGURE: 554 MONTHLY AVERAGES OF BIOCHEMICAL OXYGEN DEMAND FOR THE SURFACE STATIONS, 150 m FROM THE PLUME AT TUFTS COVE.

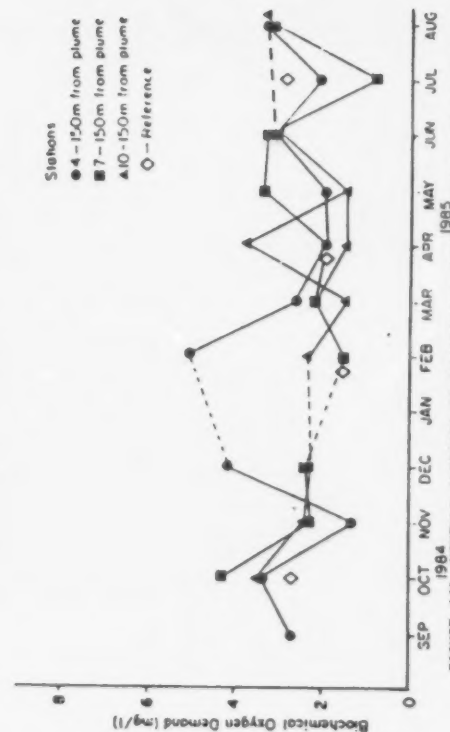


FIGURE: 555 MONTHLY AVERAGES OF BIOCHEMICAL OXYGEN DEMAND FOR THE DEPTH STATIONS, 150 m FROM THE PLUME AT TUFTS COVE.

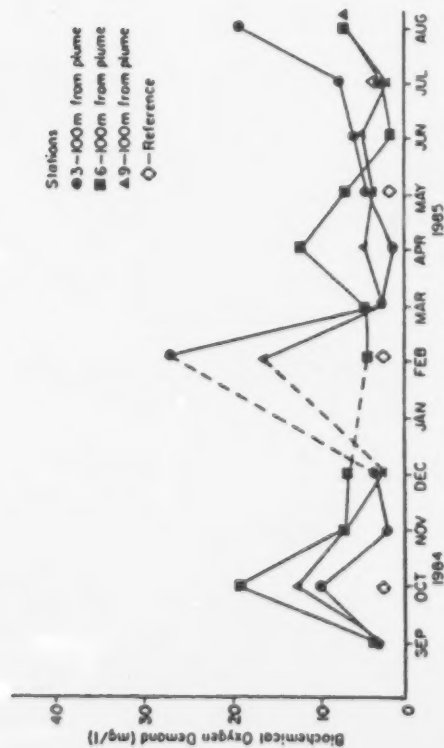


FIGURE: 552 MONTHLY AVERAGES OF BIOCHEMICAL OXYGEN DEMAND FOR THE SURFACE STATIONS, 100 m FROM THE PLUME AT TUFTS COVE.

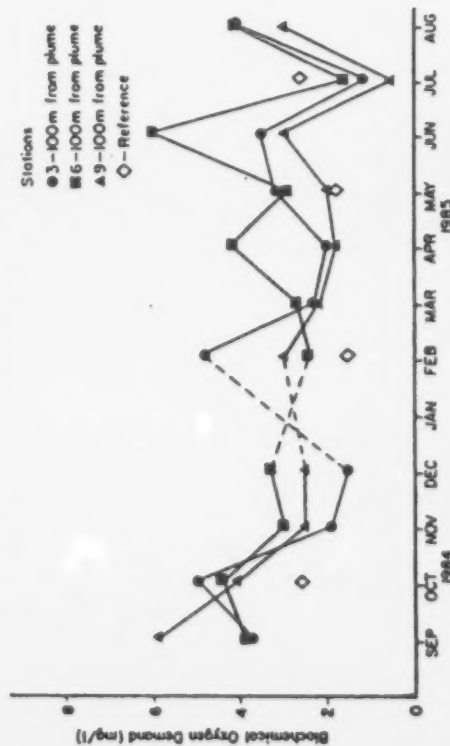


FIGURE: 553 MONTHLY AVERAGES OF BIOCHEMICAL OXYGEN DEMAND FOR THE DEPTH STATIONS, 100 m FROM THE PLUME AT TUFTS COVE.

Table 5-6 Percent reduction of Biochemical Oxygen Demand in comparison with the discharge point or the manhole at Tufts Cove outfall, due to dispersion, assimilation and removal by tides and currents.

Month	Source Strength	% reduction from the source at the 50 meter stations	% reduction between the 50 and the 100 meter stations	% reduction from the source at the 100 meter stations	% reduction between the 100 and 150 meter stations	% reduction from the source at the 150 meter stations
September 1984	42.1*	63.0 S 82.2 B	27.4 S 7.1 B	90.4 S 89.3 B	6.5 S 4.3 B	96.9 S 93.6 B
October	63.4*	64.7 S 88.1 B	12.9 S 4.8 B	77.6 S 92.9 B	8.3 S 1.2 B	85.9 S 94.1 B
November	64.1*	87.4 S 43.9 B	3.9 S 52.2 B	91.3 S 96.1 B	-1.0 S 0.8 B	90.3 S 96.9 B
December	42.1*	78.2 S 88.1 B	10.9 S 6.1 B	89.1 S 94.2 B	1.7 S -1.3 B	90.8 S 92.9 B
February 1985	45.5*	71.6 S 87.9 B	-7.0 S 4.5 B	64.6 S 92.4 B	17.4 S 1.0 B	82.0 S 93.4 B
March	64.0	79.8 S 94.9 B	6.7 S 1.4 B	86.5 S 96.3 B	8.3 S 0.4 B	94.8 S 96.7 B
April	172.0	95.8 S 98.3 B	-0.5 S 0.2 B	96.3 S 98.5 B	1.4 S -0.1 B	97.7 S 98.4 B
May	150.0	93.2 S 97.1 B	3.3 S 1.1 B	96.5 S 98.2 B	0.7 S 0.3 B	97.2 S 98.5 B
June	50.0	87.6 S 92.7 B	3.6 S -1.0 B	91.2 S 91.7 B	-0.5 S 2.0 B	90.7 S 93.7 B
July	69.0	91.7 S 95.5 B	1.3 S 2.5 B	93.0 S 98.0 B	0.7 S 0.6 B	93.7 S 98.6 B
August	140.0	78.6 S 95.6 B	13.3 S 1.5 B	91.9 S 97.1 B	4.6 S 0.5 B	96.5 S 97.6 B

* Plume
S = Surface
B = Bottom
- = assimilation

uncertain. Since the result of other parameters did not depict this level of dissipation. Daily BOD distribution patterns might be a better indication of any special conditions existing in these waters.

Duffus Street

Averages of monthly BOD values and the statistical daily analysis of the data are presented in Table B.2.2 of Appendix B. The related graphs are illustrated in figures 5.56 to 5.62.

Manhole values ranged from 30.0-115.0 mg/L and were greater than the discharge point values of 18.5 to 55.2 for every respective month. These ranges yielded a percent reduction due to dilution of 1.0 to 83.0% from the manhole to the discharge point (Table 5-16). According to the BOD values, the dilution rates were comparable to Tufts Cove, but the wastewater containment was lower in the Duffus Street outfall area.

In comparison to the other 50 meter stations, there was an apparent pooling at station 2. Station 4 was located towards the middle of the Harbour, it experienced high BOD readings indicating a possible influx of material from other sources. This parameter did not show a wastewater movement towards the Halifax Industries. Spring months were the only time when surface and bottom BOD values were closely related. In all other seasons a higher concentration of oxygen demand was retained in the surface waters and a lower percent reduction was present between these stations. This condition was due to the hydrodynamic movement of freshwater as well as the high velocity of the jet of sewage in a deep body of water. It could be assumed that better mixing of surface and bottom waters might occur at a longer distance than 150 meters.

The 100 and 150 meter stations showed a general decrease in BOD values indicating there was obvious dilution present (Table 5-7). The minimum and maximum oxygen demand concentrations were 0.4 to 304.0 mg/L which was not season dependent. The fall and winter concentrations of BOD both on the surface and bottom appeared to be higher than the spring and summer values.

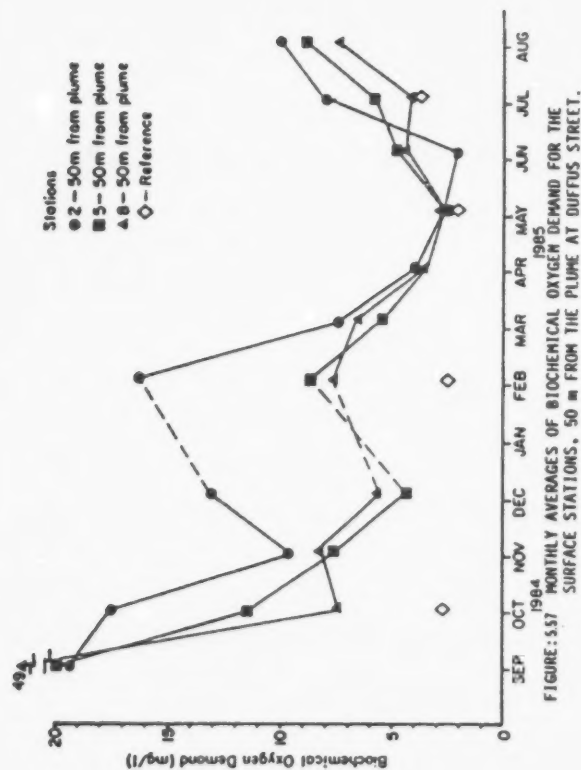


FIGURE: 557 MONTHLY AVERAGES OF BIOCHEMICAL OXYGEN DEMAND FOR THE SURFACE STATIONS, 50 m FROM THE PLUME AT DUFFUS STREET.

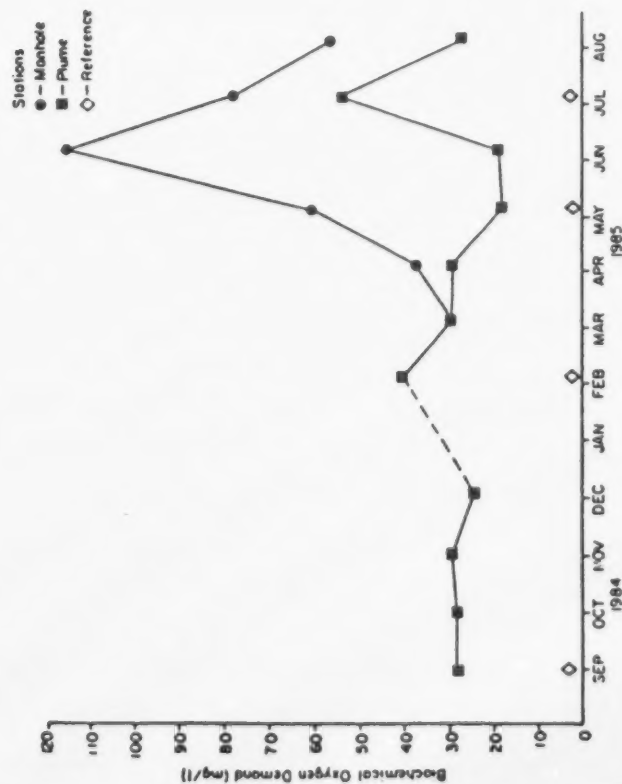


FIGURE: 556 MONTHLY AVERAGES OF BIOCHEMICAL OXYGEN DEMAND FOR THE MANHOLE AND PLUME AT DUFFUS STREET.

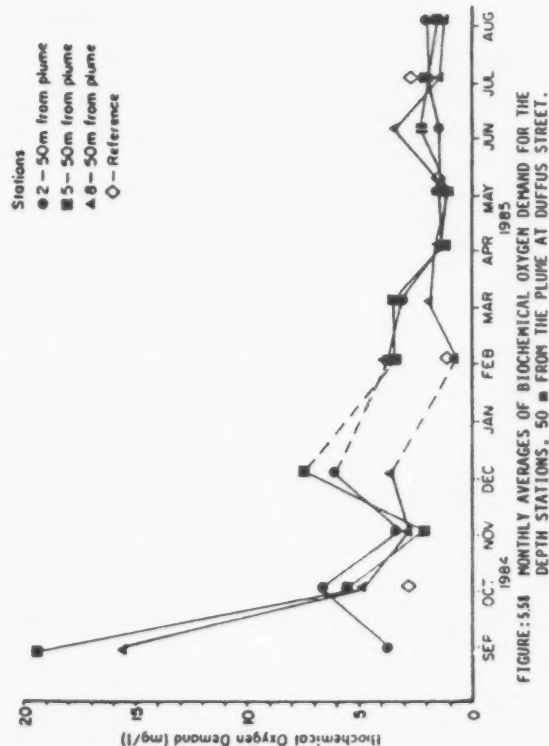


FIGURE: 558 MONTHLY AVERAGES OF BIOCHEMICAL OXYGEN DEMAND FOR THE DEPTH STATIONS, 50 m FROM THE PLUME AT DUFFUS STREET.

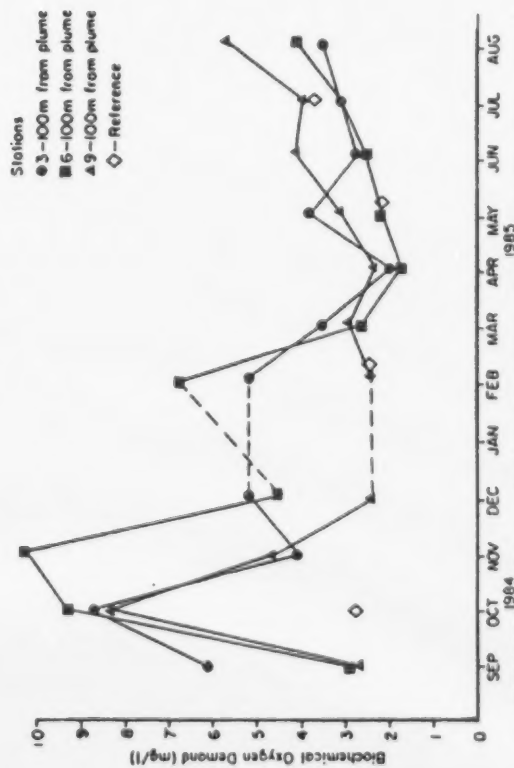


FIGURE: 559 MONTHLY AVERAGES OF BIOCHEMICAL OXYGEN DEMAND FOR THE SURFACE STATIONS, 100 m FROM THE PLUME AT DUFFUS STREET.

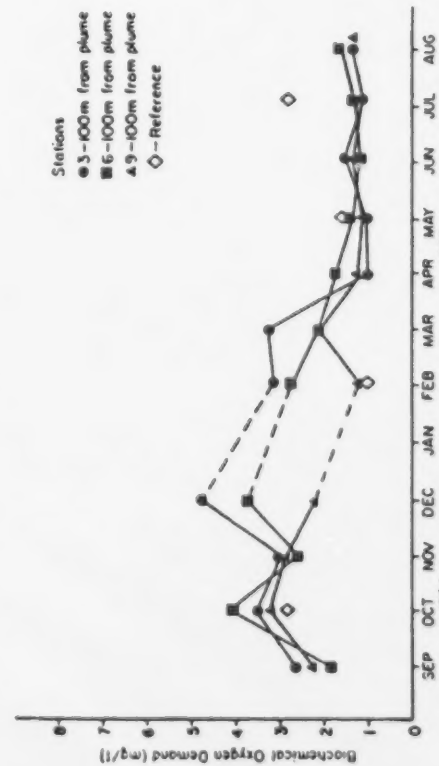


FIGURE: 560 MONTHLY AVERAGES OF BIOCHEMICAL OXYGEN DEMAND FOR THE DEPTH STATIONS, 100 m FROM THE PLUME AT DUFFUS STREET.

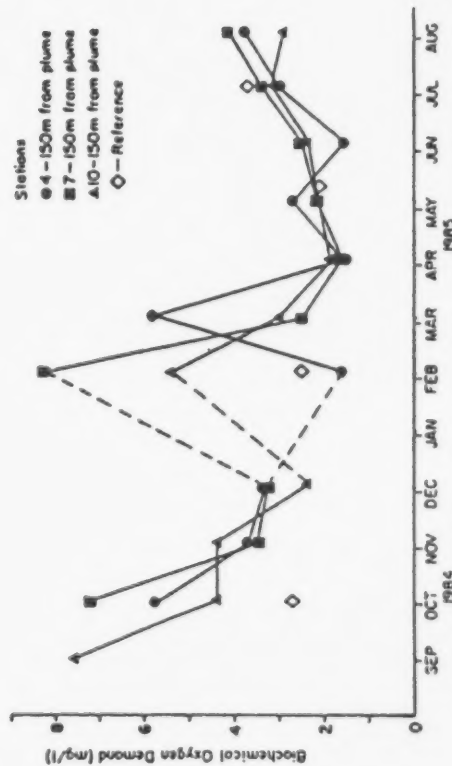


FIGURE: 561 MONTHLY AVERAGES OF BIOCHEMICAL OXYGEN DEMAND FOR THE SURFACE STATIONS, 150 m FROM THE PLUME AT DUFFUS STREET.

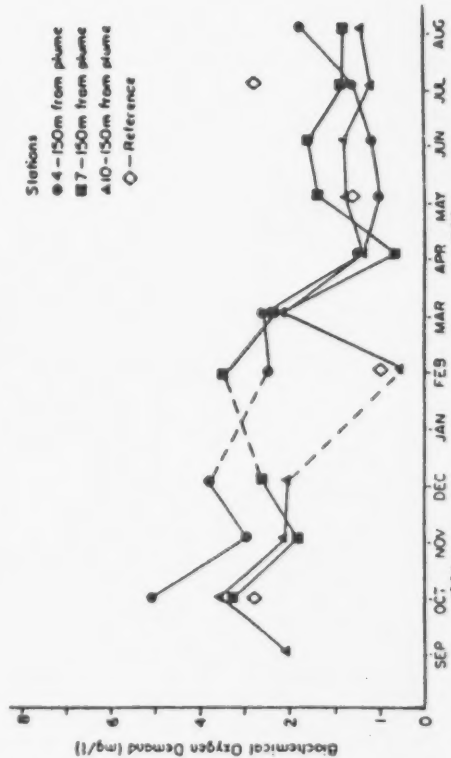


FIGURE: 562 MONTHLY AVERAGES OF BIOCHEMICAL OXYGEN DEMAND FOR THE DEPTH STATIONS, 150 m FROM THE PLUME AT DUFFUS STREET.

Table 5-7 Percent reduction of Biochemical Oxygen Demand in comparison with the discharge point or the manhole at Diffus Street outfall, due to dispersion, assimilation and removal by tides and currents.

Month	Source Strength	% reduction from the source at the 50 meter stations	% reduction between the 50 and the 100 meter stations	% reduction from the source at the 100 meter stations	% reduction between the 100 and 150 meter stations	% reduction from the source at the 150 meter stations
September 1984	28.7*	54.4 S 9.4 B	37.9 S 96.1 B	92.3 S 86.7 B	0.4 S -13.2 B	92.7 S 73.5 B
October	28.7*	80.1 S 57.7 B	7.3 S 11.9 B	87.4 S 69.6 B	-1.3 S 10.2 B	86.1 S 79.8 B
November	29.7*	90.8 S 71.7 B	-0.1 S 6.2 B	90.7 S 77.9 B	1.4 S 9.1 B	92.1 S 87.0 B
December	25.0*	76.9 S 69.2 B	9.0 S 15.1 B	85.9 S 84.3 B	2.8 S 2.3 B	88.7 S 88.6 B
February 1985	40.5*	93.0 S 73.0 B	1.2 S 15.3 B	94.2 S 88.3 B	0.5 S -0.8 B	94.7 S 87.5 B
March	30.4*	90.4 S 78.6 B	1.5 S 11.6 B	91.9 S 90.2 B	0.3 S -2.6 B	92.1 S 87.6 B
April	37.5	96.0 S 90.4 B	0.5 S -0.1 B	96.5 S 94.3 B	0.4 S 1.2 B	96.9 S 95.5 B
May	61.0	97.6 S 90.0 B	0.6 S 0.1 B	98.2 S 90.1 B	0.5 S 1.0 B	97.7 S 92.1 B
June	115.0	97.7 S 96.7 B	1.2 S 0.6 B	98.9 S 97.3 B	-0.2 S 0.9 B	98.7 S 98.2 B
July	78.0	98.1 S 94.0 B	-0.1 S 0.7 B	98.0 S 94.7 B	0.3 S 0.5 B	98.3 S 95.2 B
August	58.4	97.2 S 87.2 B	0.0 S 3.0 B	97.2 S 90.2 B	0.2 S 0.7 B	97.4 S 90.9 B

* Plume
S = Surface
B = Bottom
- = assimilation

Reference values of BOD were comparable to the bottom waters of the 150 meter stations during every season, except fall when reference values were lower. A careful comparison indicated that the surface BOD values of Duffus Street were higher than the references during fall and winter. Beyond the 150 meters of the plume waters the BOD returned to the recommended values of 5.0 to 10.0 mg/L. In comparison to the values reported by N.S.D.O.E. 1976, the values presented here appear to be not substantially lower.

Dartmouth Cove

Monthly averages and statistical analysis of the daily data are presented in Table B.2.3 of Appendix B.

A range of 39.5 to 121.5 mg/L of BOD was assayed from the manhole samples, and a range of 10.9 to 40.9 mg/L for the point of discharge, resulted in a 27.0 to 76.0% reduction due to dilution from the manhole to the outfall. The range of BOD for the Old Ferry Road discharge point was smaller, 6.8 to 27.8 mg/L. The BOD readings of this outfall were in the same range as Duffus Street values.

During the monitoring period the BOD concentrations of the surface waters were higher in every month, which was a clear sign of low vertical dilution within the water column. There was a slightly higher BOD concentration in September of 1984. Percent dilution, dissipation and assimilation also showed a similar pattern of activities. Stations 6 and 8, on most occasions had greater BOD readings which suggested a containment of the pollutants in the vicinity of the shipwrecks. In the late spring and early summer months the concentration of BOD, as well as dilution and dissipation was greater than the other seasons (Table 5-8). Minimum and maximum values observed (0.3 - 96.0 mg/L) did not correlate with the seasons or the values of the discharge points.

The BOD values of the Cove surface waters did not return to the reference levels except in spring; but the bottom stations indicated a better correlation with the reference readings. Biochemical oxygen demand within Dartmouth Cove was within the standard range. However, the concentrations observed here were in a higher range than those reported by N.S.D.O.E. 1976 (12.0 - 80.0 mg/L).

Table 5-8 Percent reduction of Biochemical Oxygen Demand in comparison with the discharge point or the manhole at Dartmouth Cove outfall, due to dispersion, assimilation and removal by tides and currents.

Month	Source Strength	% reduction from the source at the 50 meter stations	% reduction between the 50 and the 100 meter stations	% reduction from the source at the 100 meter stations	% reduction between the 100 and 150 meter stations	% reduction from the source at the 150 meter stations
September 1984	27.9*	55.6 S 86.2 B	-12.3 S -35.7 B	43.3 S 50.5 B	24.1 S 40.9 B	67.4 S 91.4 B
October	33.6*	73.2 S 83.7 B	3.1 S 1.3 B	76.3 S 82.4 B	6.4 S 6.0 B	82.7 S 88.4 B
November	44.4*	86.7 S 92.6 B	-3.9 S 2.6 B	82.8 S 95.2 B	9.5 S -0.5 B	92.3 S 94.8 B
December	35.8*	85.3 S 92.7 B	1.1 S 1.7 B	86.4 S 94.4 B	4.2 S 0.3 B	90.6 S 94.7 B
February 1985	121.5	92.4 S 95.0 B	1.3 S 1.6 B	93.7 S 96.6 B	3.1 S 0.6 B	96.8 S 97.2 B
March	51.3	91.2 S 93.2 B	-1.5 S 2.8 B	89.7 S 96.0 B	5.2 S 0.5 B	94.9 S 96.5 B
April	83.0	95.3 S 97.3 B	-0.1 S 0.3 B	95.2 S 97.6 B	0.5 S -0.1 B	95.7 S 97.5 B
May	116.0	94.0 S 97.1 B	1.0 S 1.0 B	95.0 S 98.1 B	1.3 S 0.2 B	96.3 S 98.3 B
June	39.5	86.6 S 93.2 B	-1.8 S -3.9 B	84.8 S 89.3 B	5.7 S 4.1 B	90.5 S 93.4 B
July	63.1	89.0 S 94.6 B	-0.5 S -0.6 B	88.5 S 94.0 B	3.3 S 1.0 B	91.8 S 95.0 B
August	93.0	92.1 S 96.5 B	0.4 S 0.3 B	92.5 S 96.8 B	2.4 S 0.5 B	94.9 S 97.3 B

* Plume 1 plus Plume 2
S = Surface
B = Bottom
- = assimilation

Table 5-9 Percent reduction of Biochemical Oxygen Demand in comparison with the discharge point or the manhole at Sackville Street outfall, due to dispersion, assimilation and removal by tides and currents.

Month	Source Strength	% reduction from the source at the 50 meter stations	% reduction between the 50 and the 100 meter stations	% reduction from the source at the 100 meter stations	% reduction between the 100 and 150 meter stations	% reduction from the source at the 150 meter stations
February 1985	175.0	93.4 S 96.5 B	3.1 S 1.9 B	96.5 S 98.4 B	0.4 S 0.0 B	96.9 S 98.4 B
March	260.0	98.4 S 99.0 B	0.7 S 0.0 B	99.1 S 99.0 B	0.0 S 0.1 B	99.1 S 99.1 B
April	81.5	93.3 S 96.8 B	4.4 S -0.1 B	97.7 S 96.7 B	0.2 S 0.5 B	97.9 S 97.2 B
May	52.9 ^a	84.1 S 95.1 B	8.8 S -0.1 B	92.9 S 95.0 B	3.6 S 0.7 B	95.5 S 95.7 B
June	100.0	91.7 S 96.6 B	4.5 S 0.5 B	96.2 S 98.1 B	0.8 S 0.2 B	97.0 S 98.3 B
July	121.0	93.2 S 97.1 B	3.1 S 0.3 B	96.3 S 97.4 B	0.1 S -0.3 B	96.4 S 97.1 B
August	127.0	94.0 S 98.5 B	3.4 S 0.1 B	97.4 S 98.6 B	0.1 S 0.1 B	97.5 S 98.7 B

^a Plume
S = Surface
B = Bottom
- = assimilation

Sackville Street

Monthly averages and the relevant statistical analysis of the daily data are presented in Table B.2.4 of Appendix B.

The BOD concentrations at the point of discharge ranged from 16.1 to 52.9 mg/L, and the manhole samples BOD content ranged from 81.5 to 260.0 mg/L indicating a high 74.0 to 92.0% reduction due to dilution (Table 5-16). The manhole samples had the highest range of variations observed.

Greater amounts of BOD were being discharged during the spring season; which fact was obvious both from the initial loading and the values present at the stations. In general, the surface waters contained higher concentrations of oxygen demanding waste than the bottom stations for every respective month.

By assessment of BOD concentrations, there were indications of dilution and dissipation in the waters of this outfall area; and the uniform percent reduction was witness to this fact (Table 5-9). The surface values of BOD did not return to the reference values, indicating hydrodynamic freshwater movement. There was a close correlation between the amount of BOD in the bottom plume waters and reference stations. The values of oxygen demand within the 100 and 150 meter plume waters were within the 5.0 to 10.0 mg/L of the recommended limits.

Pier "A"

Monthly averages of the data as well as the statistical analysis of the daily results are presented in Table B.2.5 of Appendix B.

A range of 62.0 to 141.5 mg/L of BOD was present in the manhole of Pier "A", and a range of 17.4 to 63.5 mg/L, at the discharge point which resulted in a reduction due to dilution of 42.0 to 83.0% from the manhole to the outfall (Table 5-16). The mechanisms of dilution, dissipation or assimilation was not evident; since other parameters had indicated a low level of reduction due to dilution (Table 5-10A & B).

Table 5-10A Percent reduction of Biochemical Oxygen Demand in comparison with the discharge point or the manhole at Pier "A" outfall, due to dispersion, assimilation and removal by tides and currents (plume 1).

Month	Source Strength	% reduction from the source at the 200 meter stations	% reduction between the 200 and the 400 meter stations	% reduction from the source at the 400 meter stations	% reduction between the 400 and 450 meter stations	% reduction from the source at the 450 meter stations
February 1985	135.0	95.3 98.1	0.3 -0.7	95.6 97.4	1.9 1.0	97.6 98.4
March	141.5	96.4 98.2	0.7 0.1	97.1 98.3	-0.2 -0.1	96.9 98.2
April	105.0	96.7 98.5	1.0 0.0	97.7 98.5	0.1 0.2	97.6 98.7
May	40.3 ^a	85.1 95.0	-4.2 0.2	89.3 94.8	0.9 0.7	95.5 98.2
June	62.0	90.2 95.0	2.7 1.5	92.9 96.5	3.5 0.8	95.4 97.3
July	128.0	93.1 97.6	3.1 1.4	96.2 98.0	-0.8 -0.4	95.4 97.6
August	84.0	95.2 97.9	1.1 0.4	96.3 98.3	-1.0 -0.4	95.3 97.9

^a Plume
S = Surface
B = Bottom
- = assimilation

Table 5-10B Percent reduction of Biochemical Oxygen Demand in comparison with the discharge point at Pier "A" outfall, due to dispersion, assimilation and removal by tides and currents (plume 2).

Month	Source Strength	↓ reduction from the source at the 200 meter stations	↓ reduction between the 200 and the 400 meter stations	↓ reduction from the source at the 400 meter stations	↓ reduction between the 400 and 450 meter stations	↓ reduction from the source at the 450 meter stations
February 1985	38.5	89.4 S 94.8 B	-3.6 S 0.8 B	93.0 S 94.0 B		
March	33.7	90.2 S 91.4 B	4.7 S -2.1 B	85.5 S 93.5 B		
April	25.4	88.6 S 94.1 B	-3.1 S -0.4 B	91.7 S 94.5 B		
May	40.0	90.3 S 96.3 B	-1.5 S -0.2 B	91.8 S 96.5 B		
June	28.7	89.5 S 90.0 B	-1.1 S -4.4 B	90.6 S 94.4 B		
July	35.7	81.2 S 90.8 B	-4.0 S -0.8 B	85.2 S 91.6 B		
August	23.8	83.6 S 94.1 B	0.8 S 2.9 B	82.8 S 91.2 B		

S = Surface
B = Bottom
- = assimilation

The surface waters of Pier "A", at every station were higher than the bottom waters. Comparison between the stations close to either discharge point indicated slightly higher BOD values in the Pier. Observed maximum and minimum values occurred in summer and spring. Generally there was a uniform pattern of distribution within the area.

The surface waters had greater BOD values than the reference stations; but the bottom stations had similar values. In either case the waters were within the standard of 5.0 to 10.0 mg/L. Average BOD values were similar to that reported by N.S.D.O.E., 1976.

Analysis and Discussion of the Biochemical Oxygen Demand Profiles

The BOD profiles are the graphic presentation of Biochemical Oxygen Demand and are presented in Tables B.2.1 to B.2.5 of Appendix B. The reference values are also interpolated to illustrate the removal rate within the monitored area. Hence, the BOD contour lines between the 150 meter stations and reference sites, located in the middle of the Harbour are not presented.

Tufts Cove

The BOD profiles for this site are presented in figures 5.63 to 5.84. These figures indicate high BOD values extending further from the discharge point at the surface than at the bottom. The BOD contours lines also had more erratic patterns of distribution on the surface, primarily due to the sewage override, which resulted from the upward jet of sewage and wind induced activities. In seven of the eleven months, the reference BOD values had been reached at the surface, within a 150 meter radius of the discharge point. The worst conditions of BOD dispersion occurred during the summer months.

The bottom waters had shown a more uniform pattern of distribution and the reference values were reached within a shorter distance than the surface. Reduction due to dilution also supports the fact that there were more concentrations of the BOD on the surface for a longer distance. For eight of the eleven months studied the reference values were reached within 150 meters.

Fig. 5.63 Surface profiles of the monthly average of
BOD(mg/l) at Tufts Cove outfall,
September, 1984 . R= 2.7 mg/l(reference value)

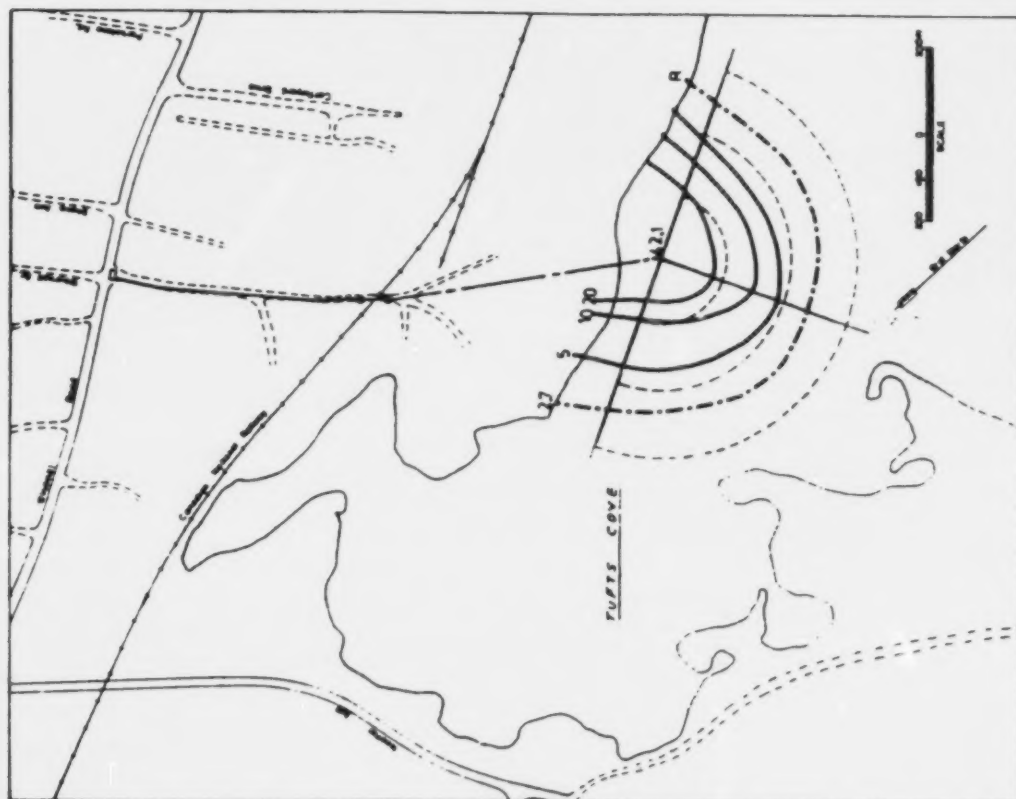


Fig. 5.64 Depth profiles of the monthly average of
BOD(mg/l) at Tufts Cove outfall,
September, 1984 . R= 2.7 mg/l(reference value)

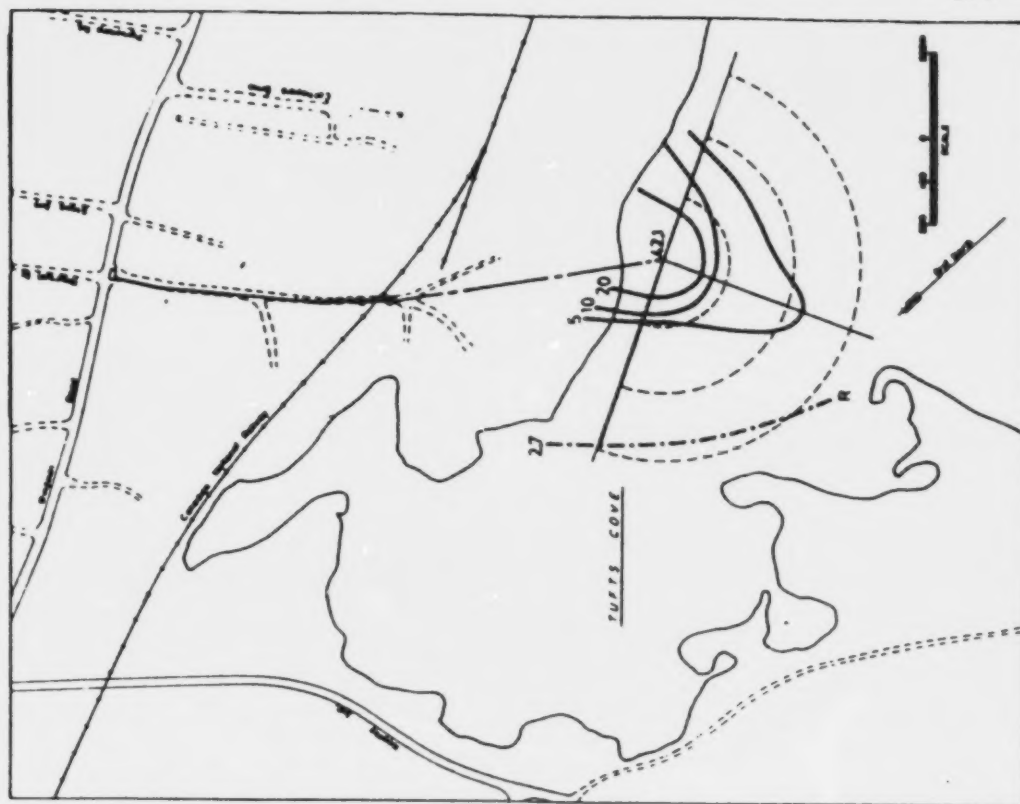


Fig. 5.65 Surface profiles of the monthly average of BOD(mg/l) at Tufts Cove outfall, October, 1984. $R=2.7$ mg/l (reference value)

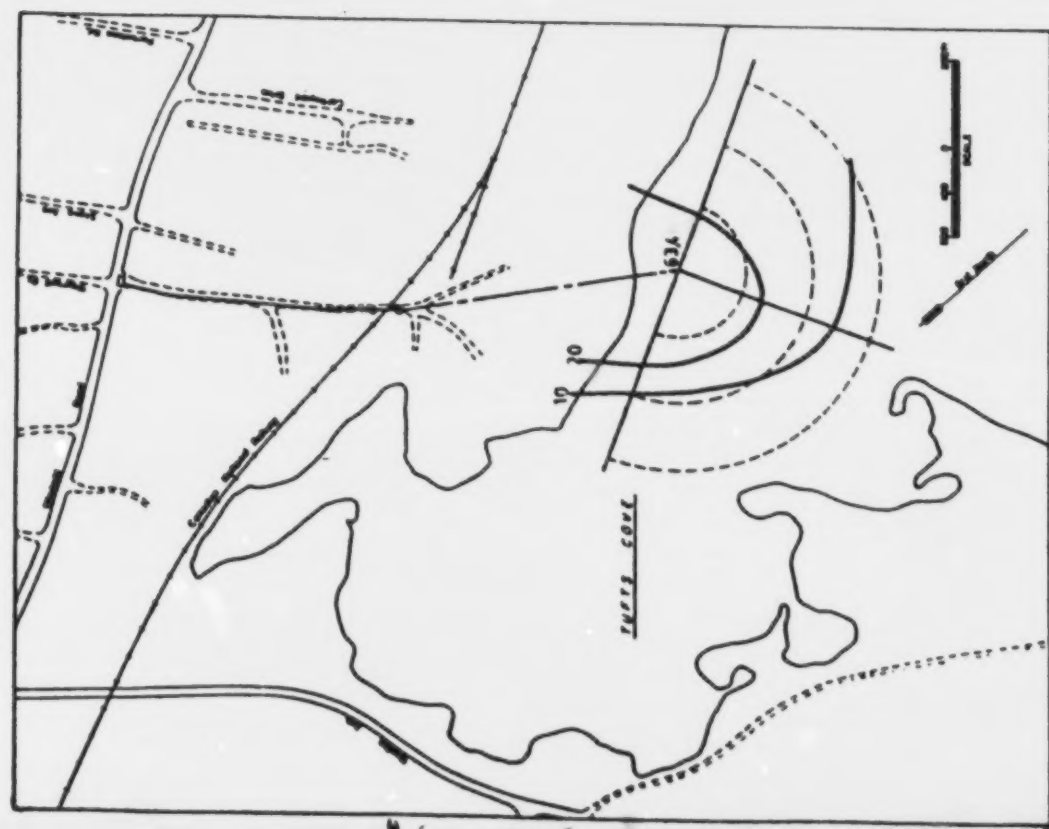


Fig. 5.66 Depth profiles of the monthly average of BOD(mg/l) at Tufts Cove outfall, October, 1984. $R=2.7$ mg/l (reference value)

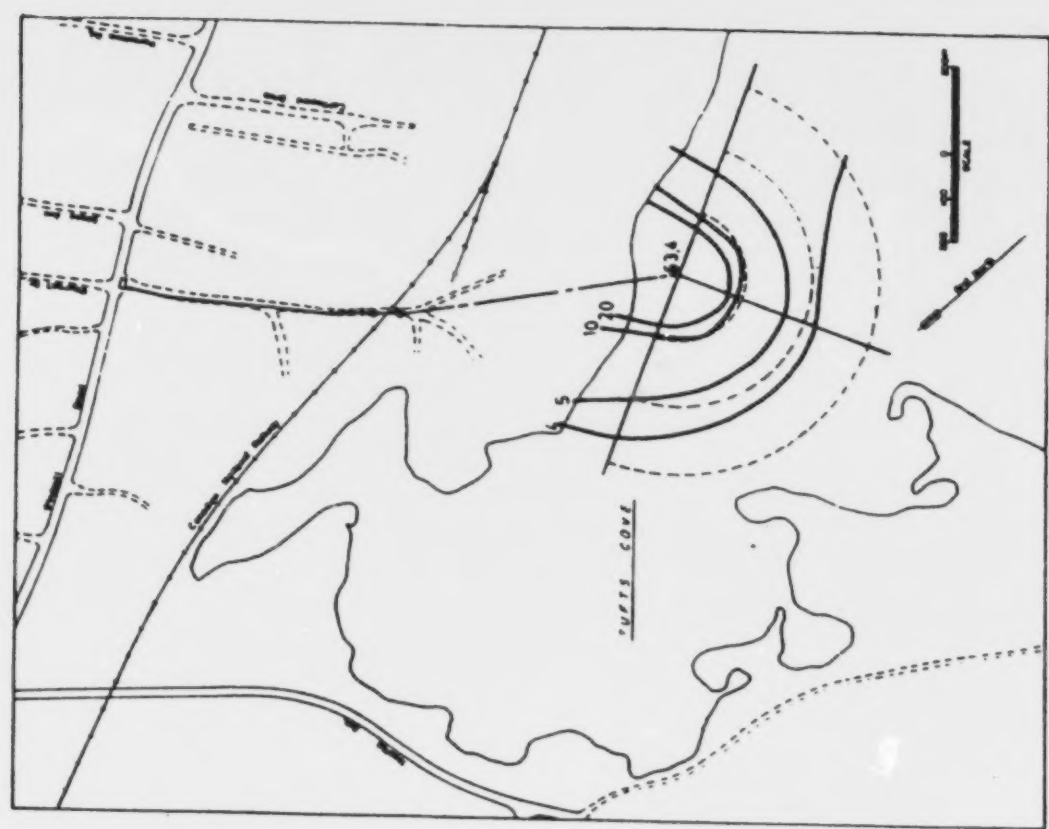


Fig. 5.67 Surface profiles of the monthly average of BOD (mg/l) at Tufts Cove outfall, November, 1984. R = 2.7 mg/l (reference value)

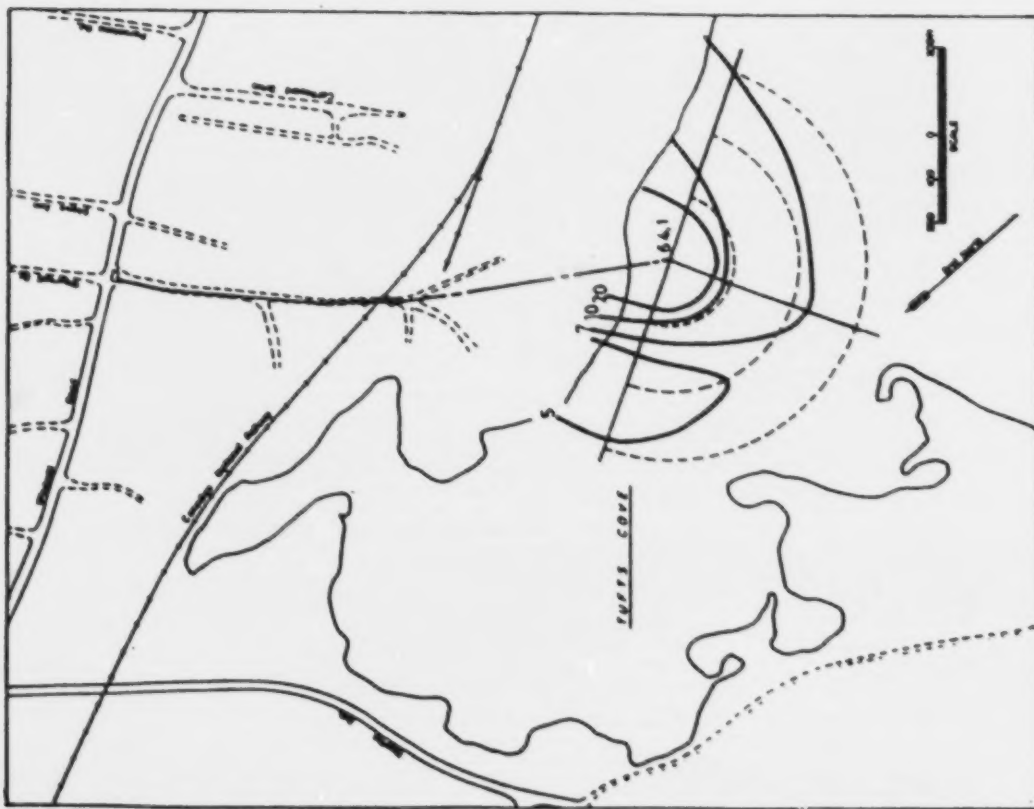


Fig. 5.68 Depth profiles of the monthly average of BOD (mg/l) at Tufts Cove outfall, November, 1984. R = 2.7 mg/l (reference value)

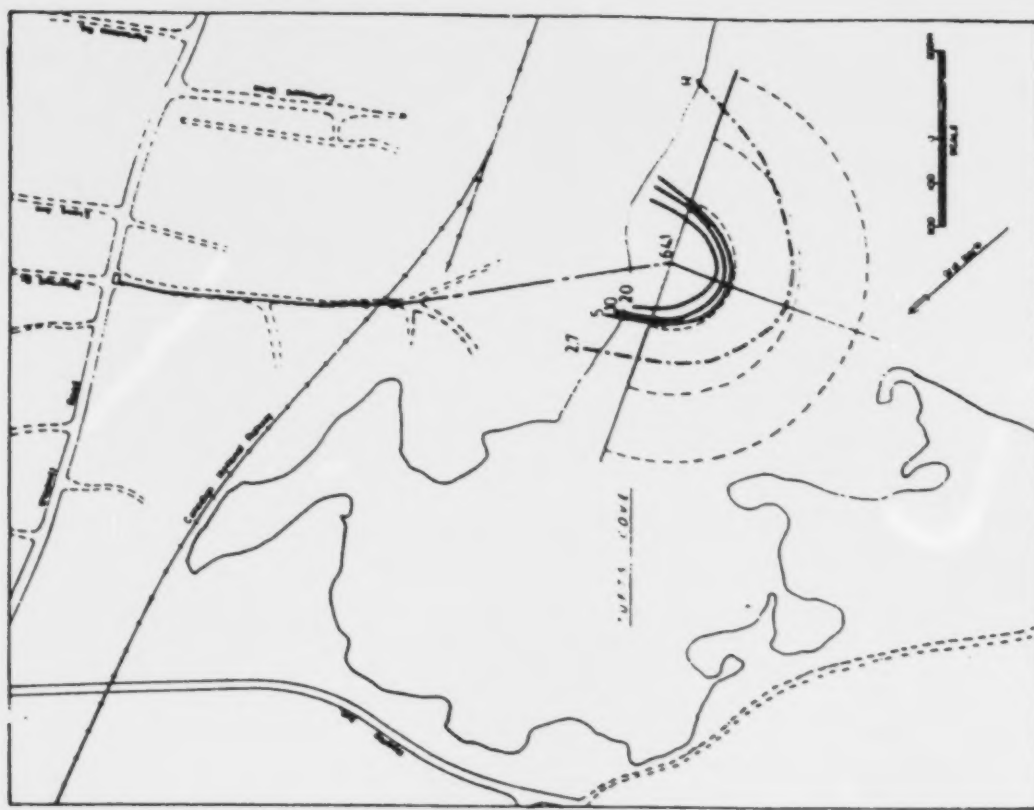


Fig. 5.69 Surface profiles of the monthly average of BOD (mg/l) at Tufts Cove outfall, December, 1984. $R = 2.7$ mg/l (reference value)

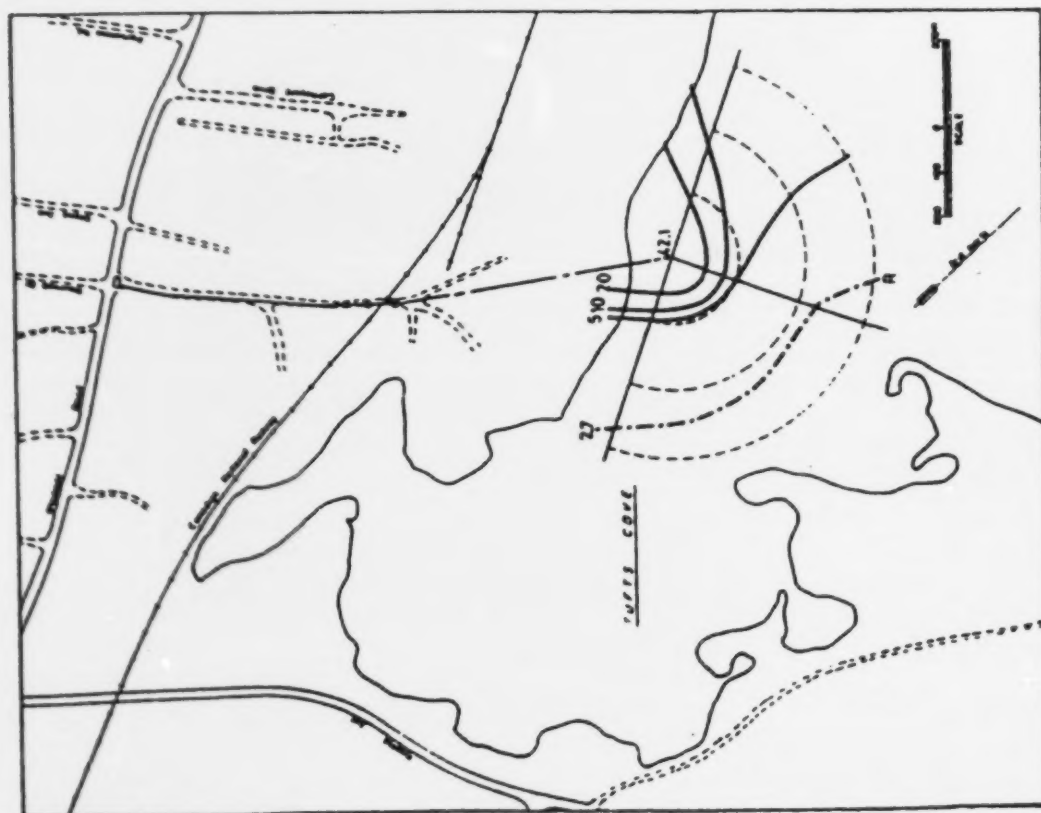


Fig. 5.70 Depth profiles of the monthly average of BOD (mg/l) at Tufts Cove outfall, December, 1984. $R = 2.7$ mg/l (reference value)

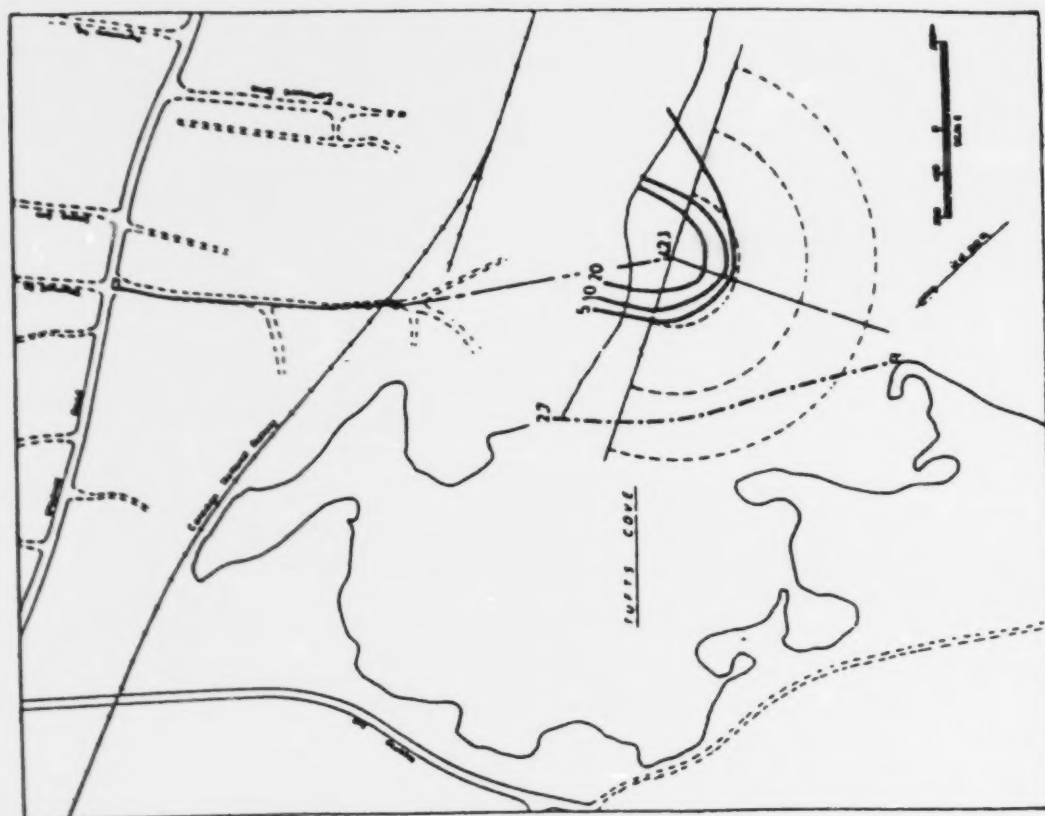


Fig. 5.71 Surface profiles of the monthly average of
BOD (mg/l) at Tufts Cove outfall,
February , 1985 . R= 2.8 mg/l(reference value)

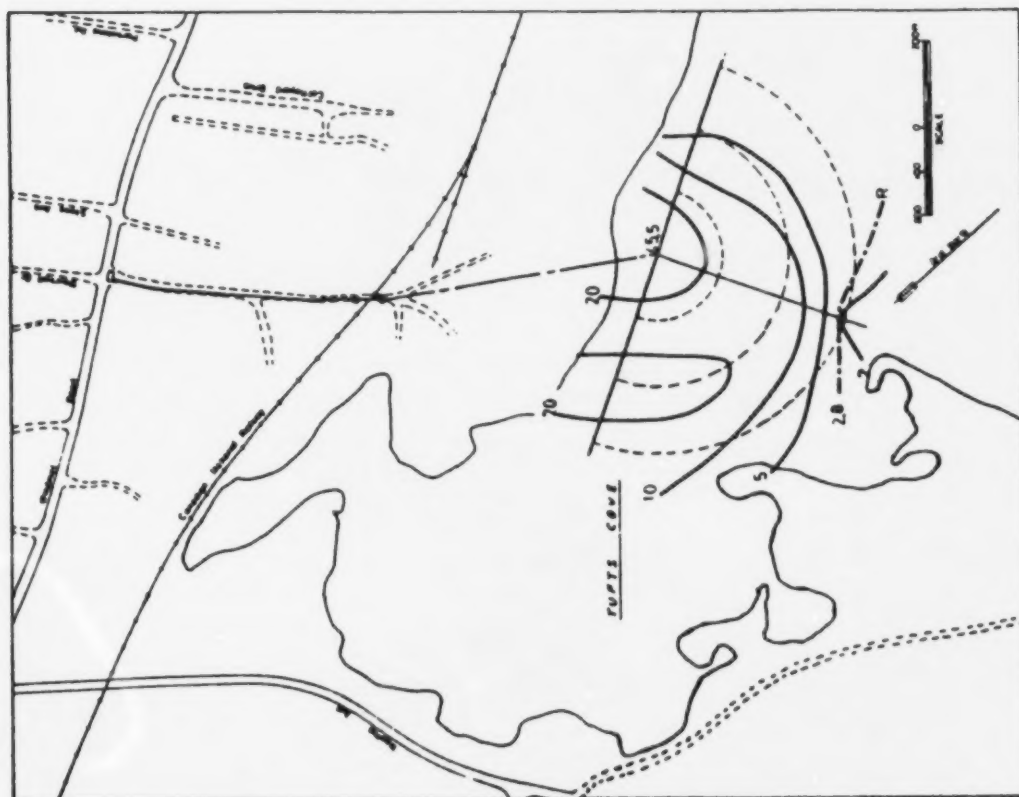


Fig. 5.72 Depth profiles of the monthly average of
BOD (mg/l) at Tufts Cove outfall,
February , 1985 . R= 1.5 mg/l(reference value)

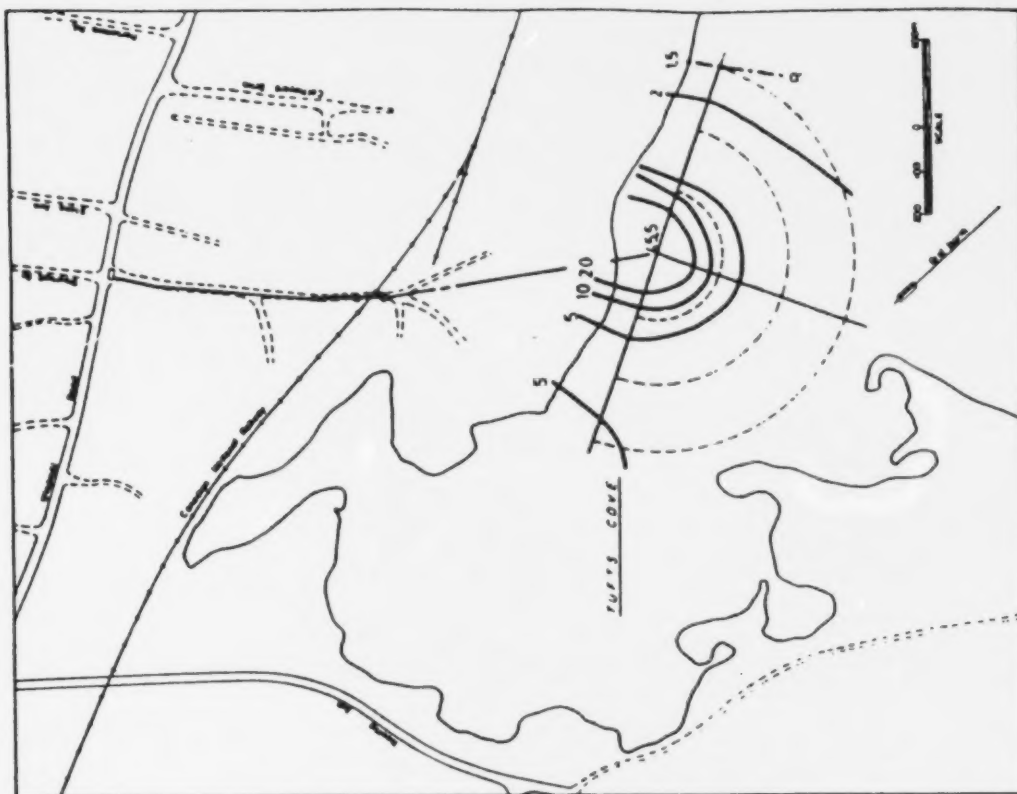


Fig. 5.73 Surface profiles of the monthly average of BOD(mg/l) at Tufts Cove outfall, March, 1985. $R=2.8$ mg/l(reference value)

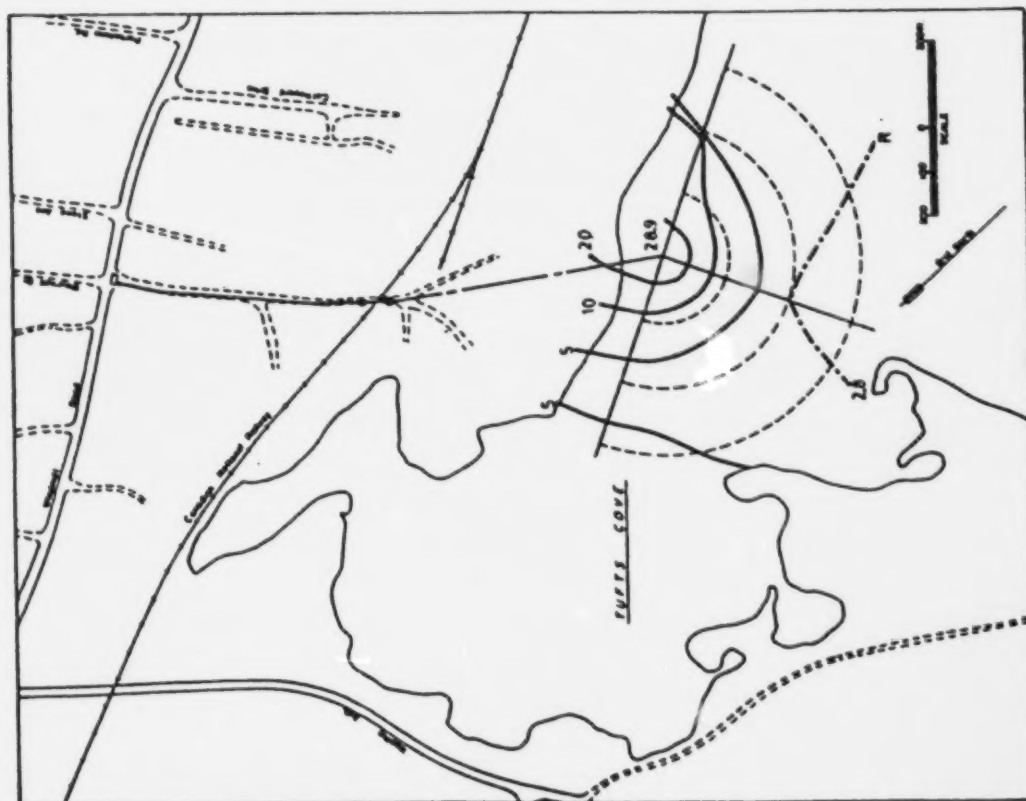


Fig. 5.74 Depth profiles of the monthly average of BOD(mg/l) at Tufts Cove outfall, March, 1985. $R=1.5$ mg/l(reference value)

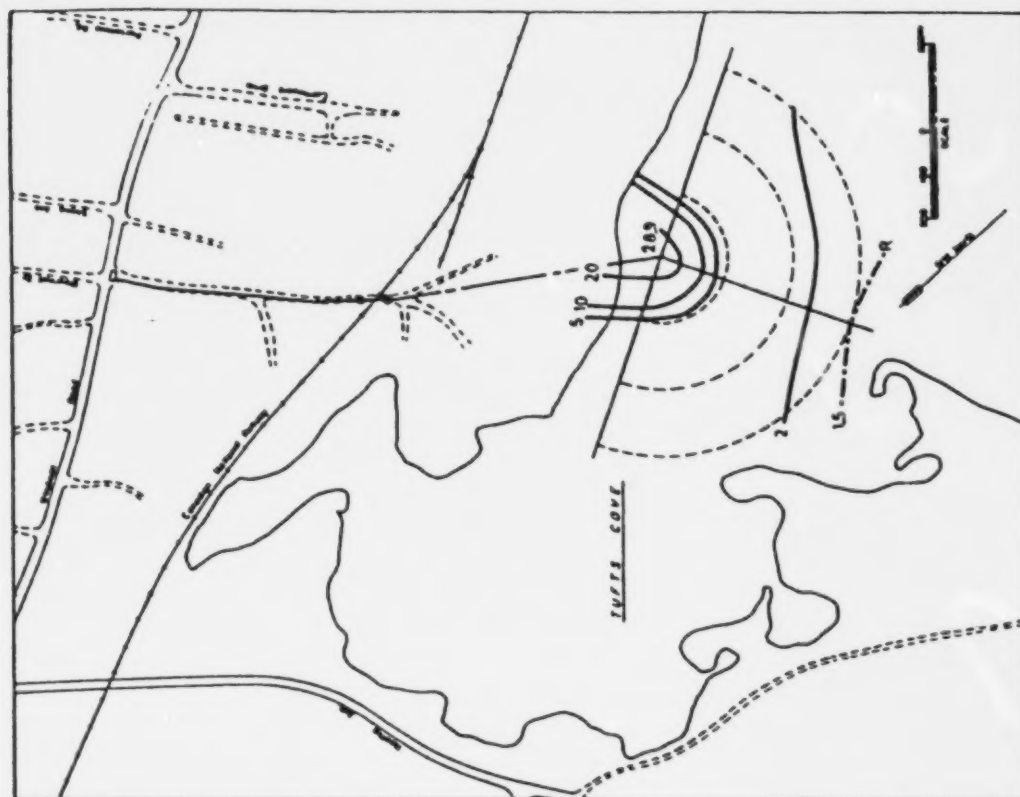


Fig. 5.76 Depth profiles of the monthly average of BOD(mg/l) at Tufts Cove outfall, April, 1985. R= 1.9 mg/l(reference value)

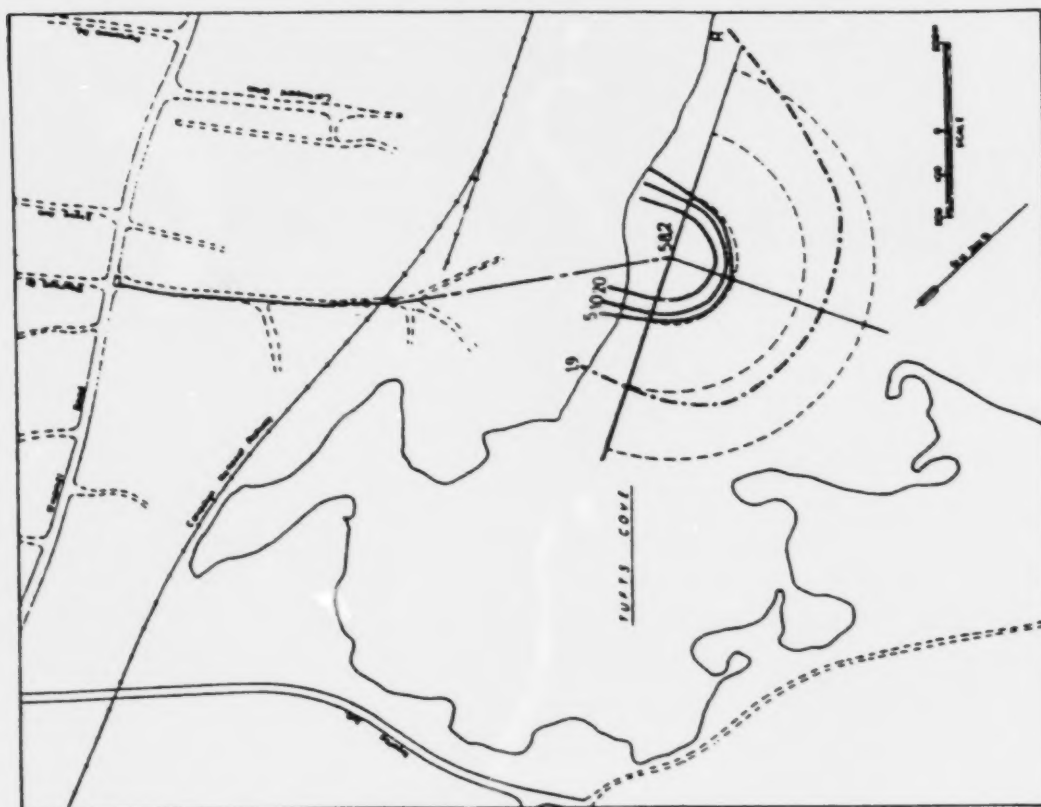


Fig. 5.75 Surface profiles of the monthly average of BOD(mg/l) at Tufts Cove outfall, April, 1985. R= 2.0 mg/l(reference value)

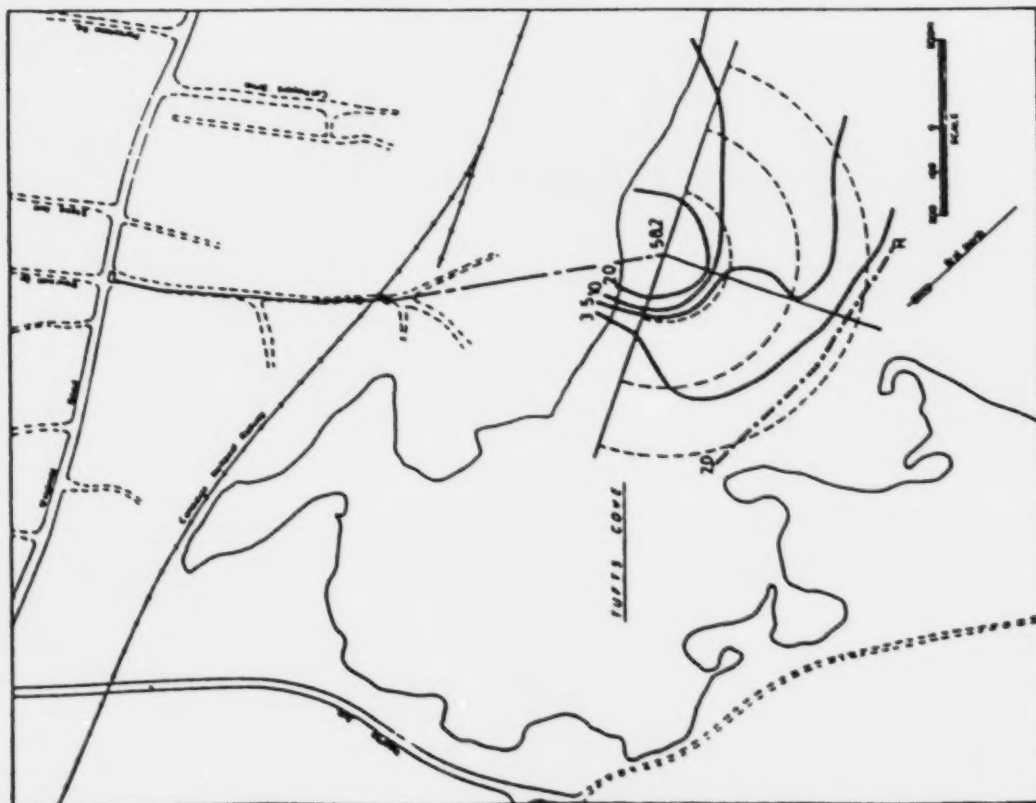


Fig. 5.77 Surface profiles of the monthly average of BOD(mg/l) at Tufts Cove outfall, May, 1985 . R= 2.0 mg/l(reference value)

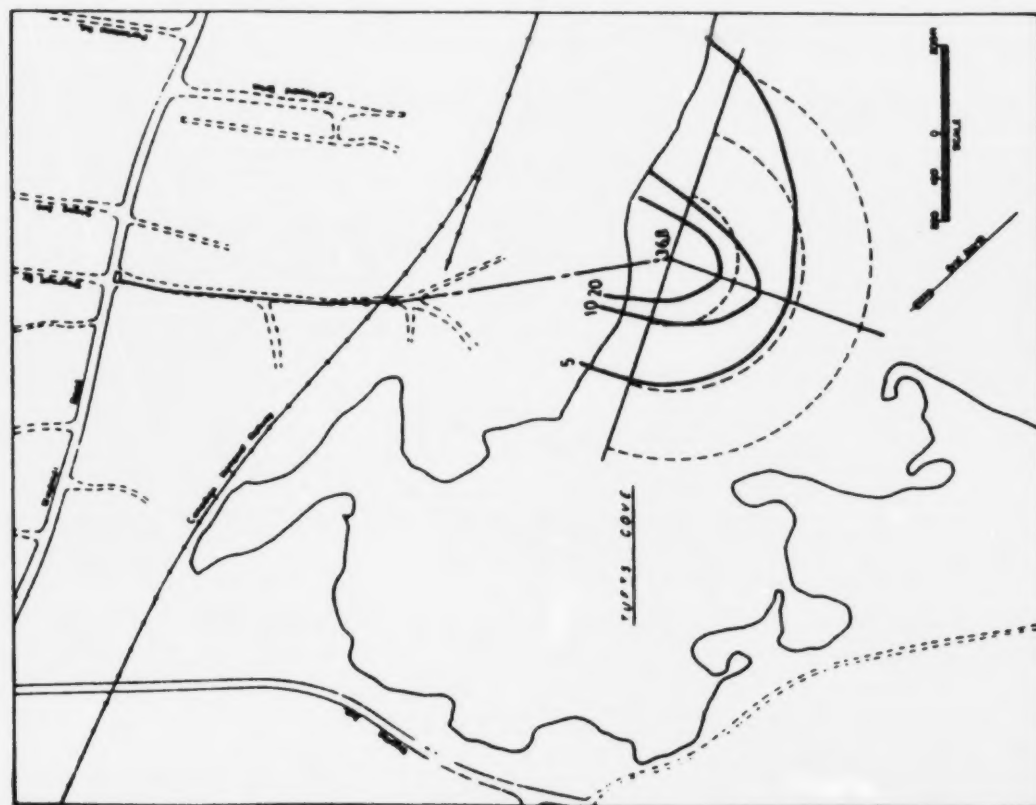


Fig. 5.78 Depth profiles of the monthly average of BOD(mg/l) at Tufts Cove outfall, May, 1985 . R= 1.9 mg/l(reference value)

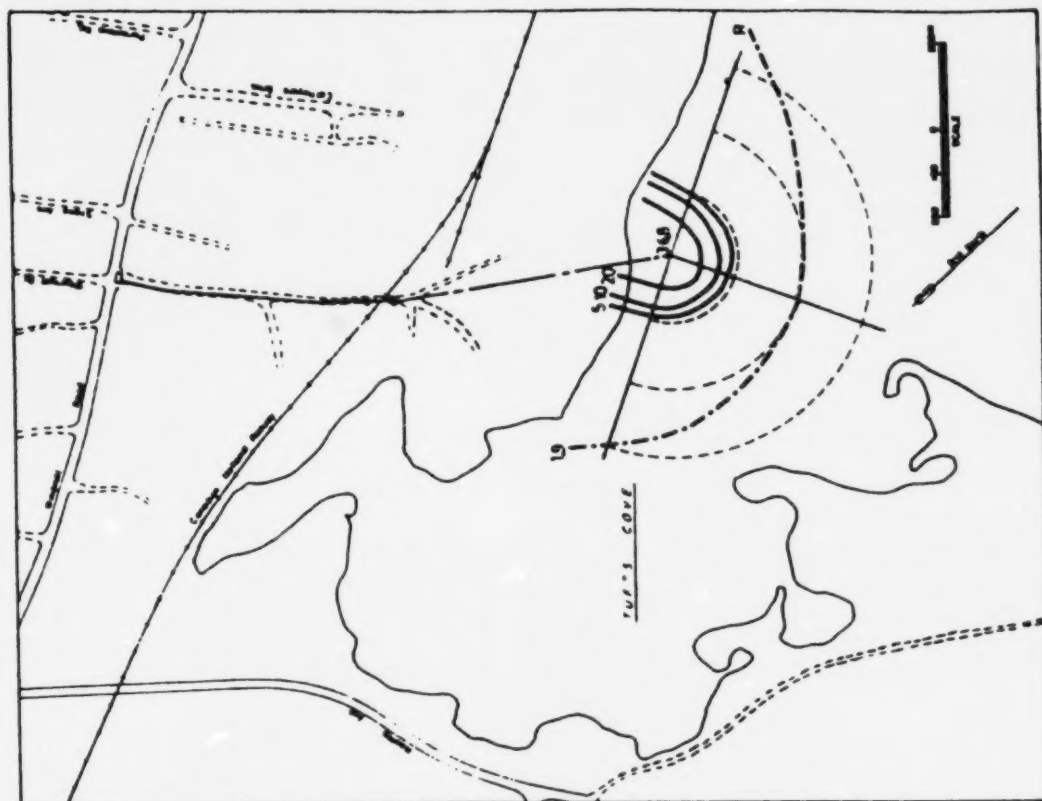


Fig. 5.79 Surface profiles of the monthly average of BOD(mg/l) at Tufts Cove outfall, June, 1985. R=2.0 mg/l(reference value)

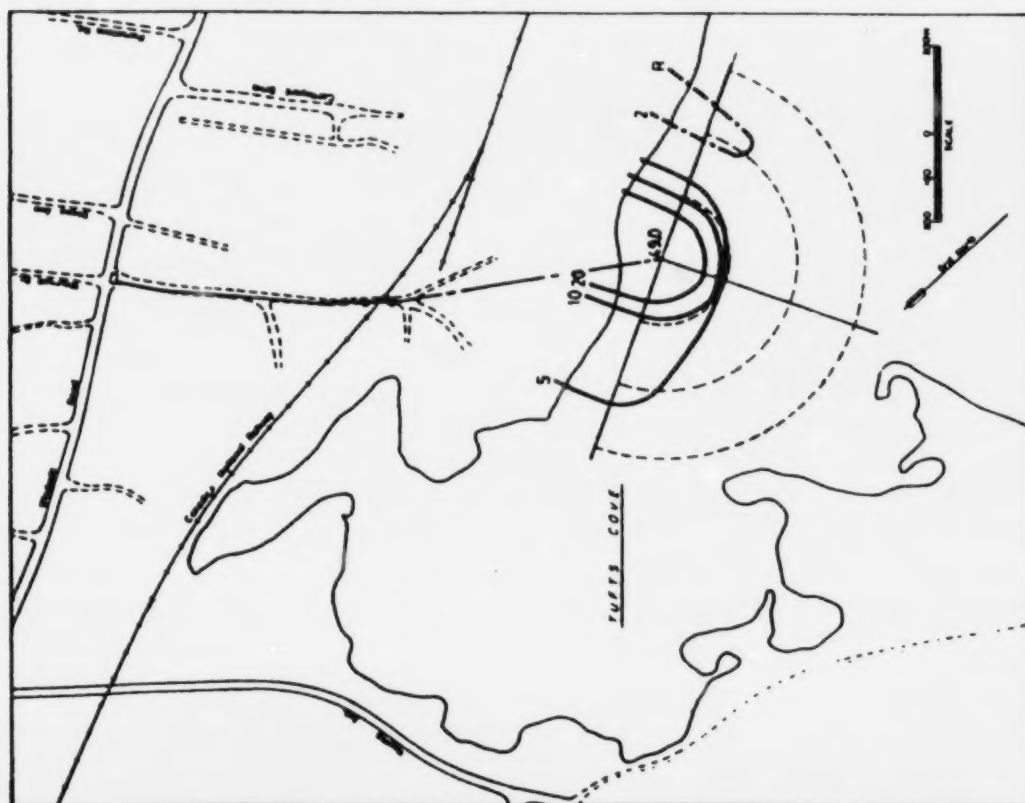


Fig. 5.80 Depth profiles of the monthly average of BOD(mg/l) at Tufts Cove outfall, June, 1985. R= 1.9 mg/l(reference value)

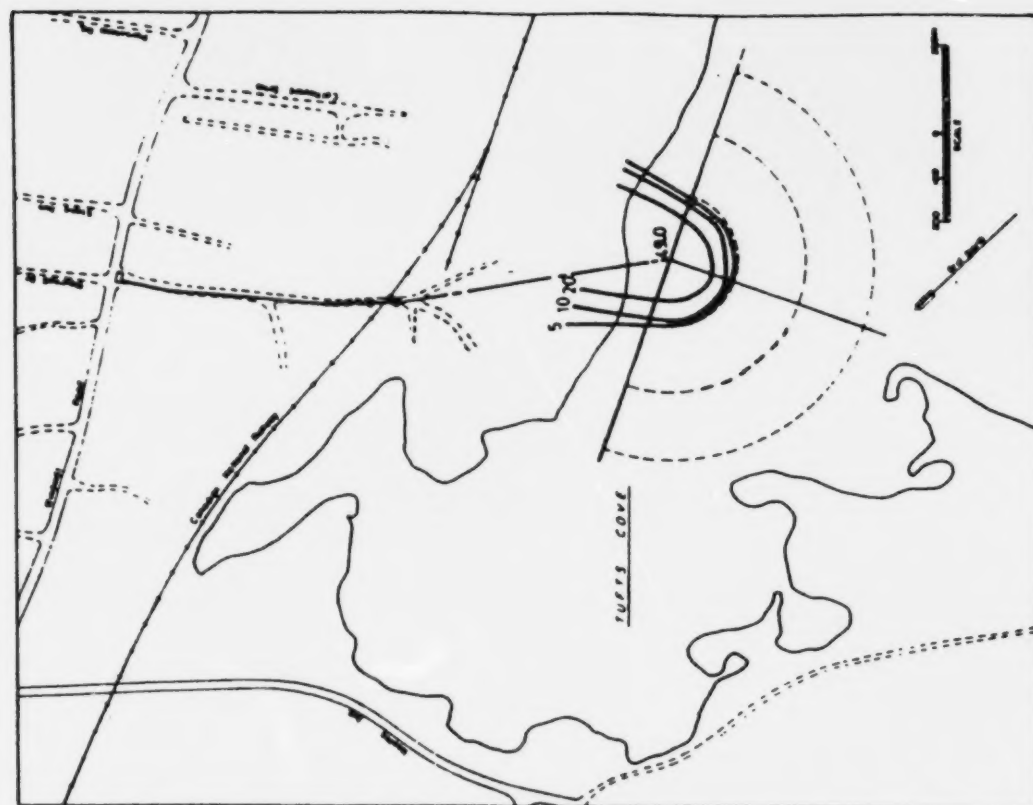


Fig. 5.82 Depth profiles of the monthly average of BOD (mg/l) at Tufts Cove outfall, July, 1985. $R = 2.8$ mg/l (reference value)

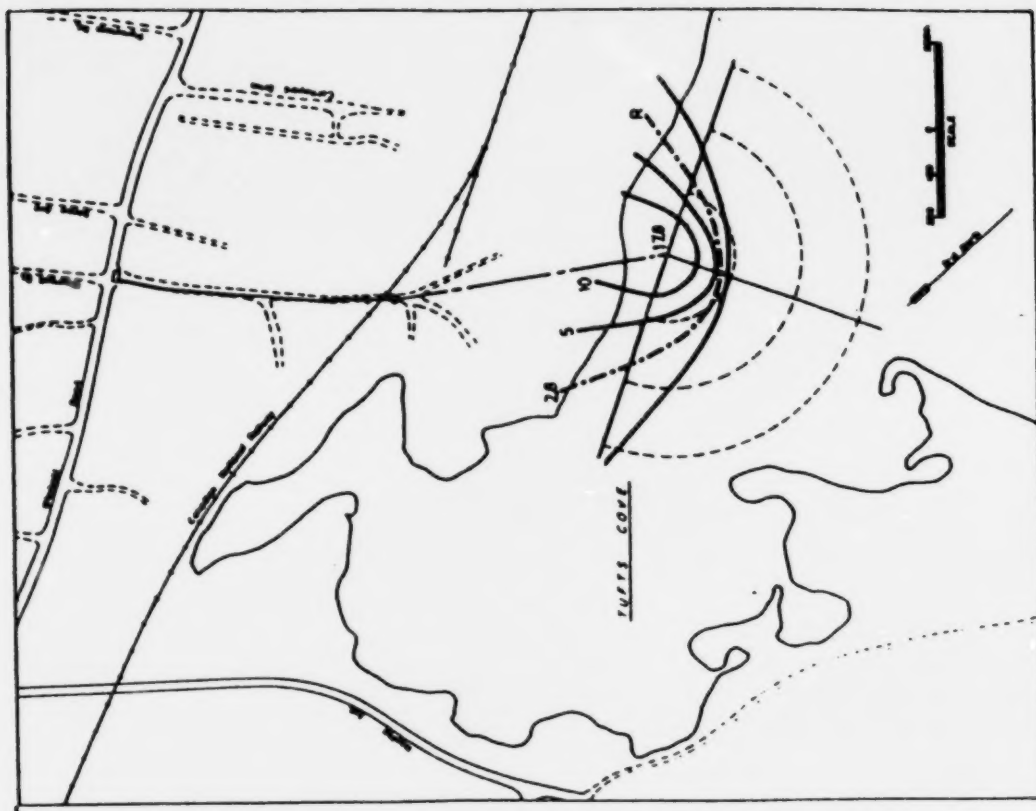


Fig. 5.81 Surface profiles of the monthly average of BOD (mg/l) at Tufts Cove outfall, July, 1985. $R = 3.7$ mg/l (reference value)

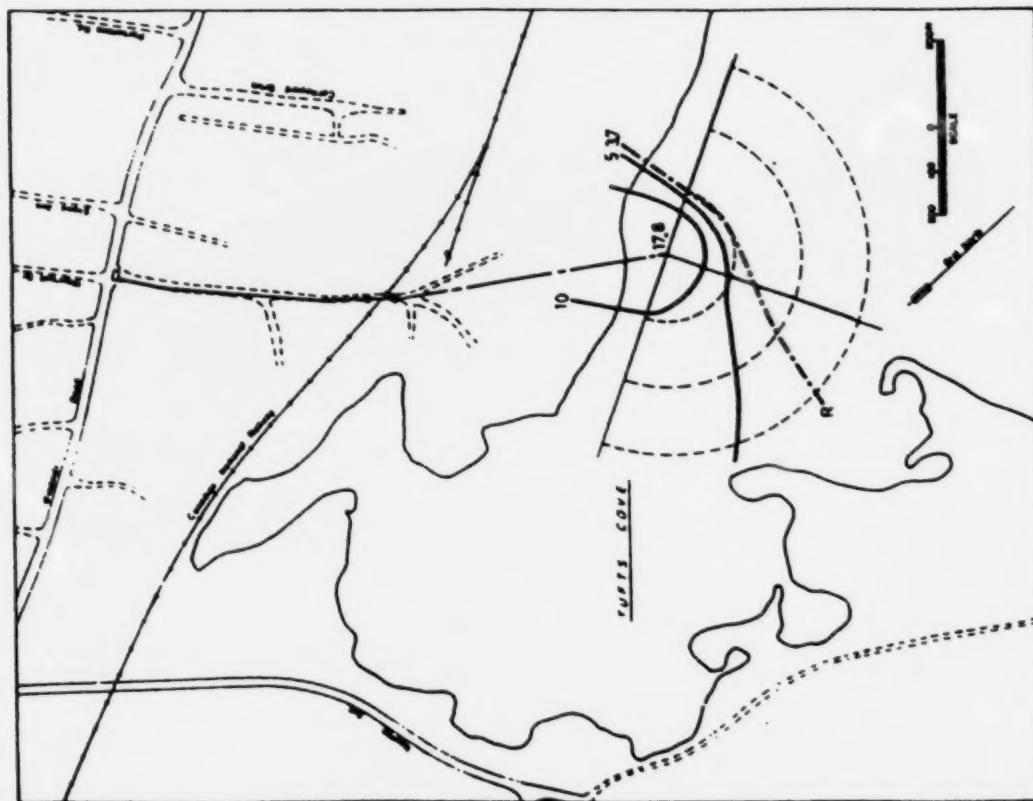


Fig. 5.83 Surface profiles of the monthly average of BOD (mg/l) at Tufts Cove outfall, August, 1985. $R = 3.7$ mg/l (reference value)

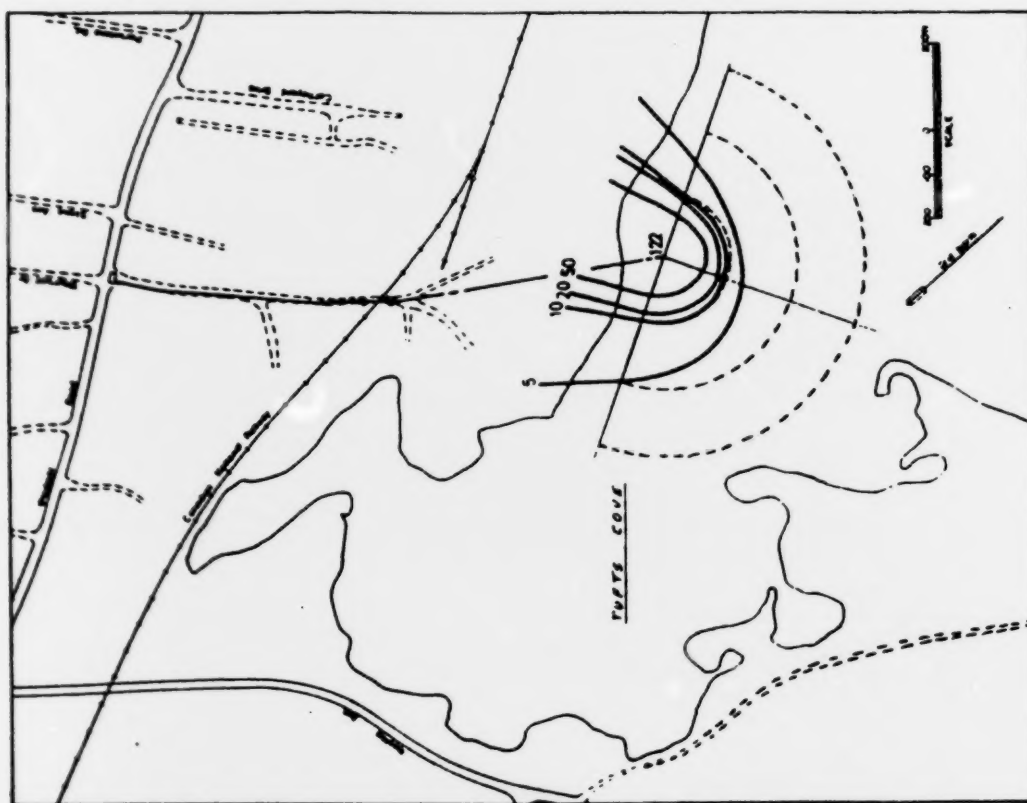
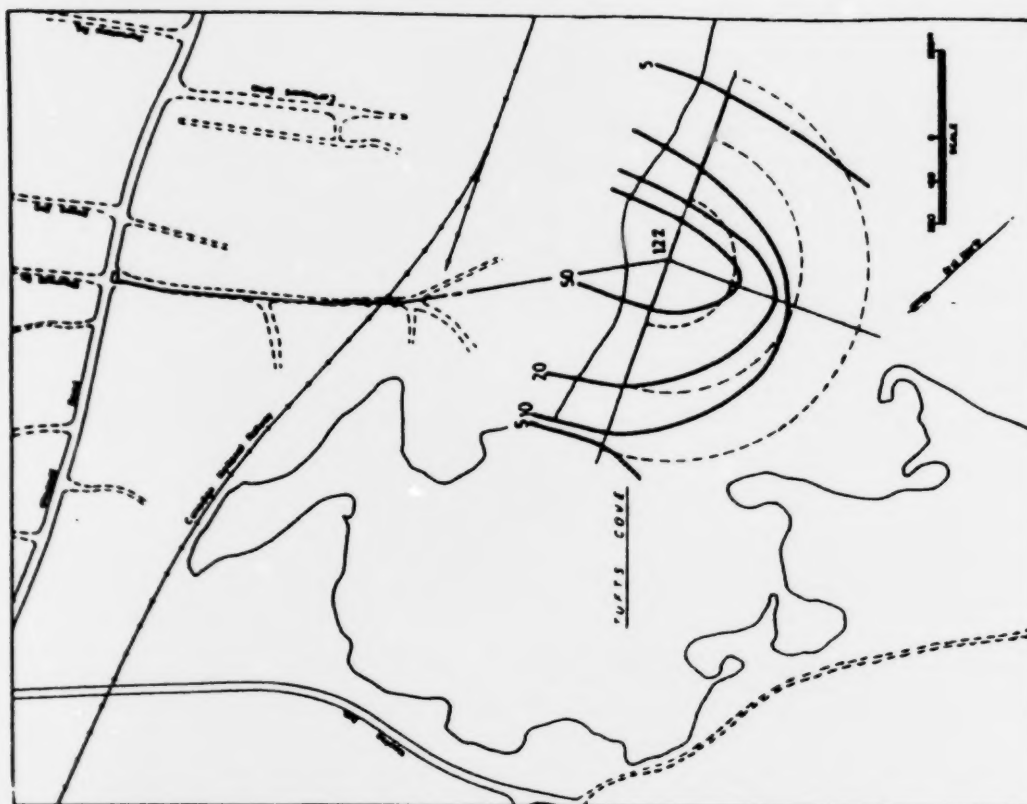


Fig. 5.84 Depth profiles of the monthly average of BOD (mg/l) at Tufts Cove outfall, August, 1985. $R = 2.8$ mg/l (reference value)



In general, during eight of the eleven months the 5 mg/L BOD limit was reached within both the surface and bottom of the plume waters. The primary mechanism of reduction was dilution, removal and a slow rate of assimilation considering the physical characteristics of this area. The containment of the organics in the northern section of the Cove was evident emphasizing the physical limitations of the Cove. The highest BOD values existed in August and extended the farthest from the discharge point.

Duffus Street

The figures 5.85 to 5.106 illustrate the BOD profiles within this outfall area.

The surface profiles had a less uniform pattern of distribution than the bottom profiles. The profiles also showed further dispersion of the organics on the surface of the outfall area, emphasizing the hydrodynamic overridden of freshwater sewage. In nine of the eleven months the reference values for the surface had been reached within 150 meters of the outfall.

The depth profiles closely resemble the corresponding surface profiles, yet extended for a shorter distance from the discharge point. The bottom profiles clearly show a pooling of the contaminants within the outfall area due to the swirling action of landward currents around the Volvo Wharf. The seaward currents caused the plume to move along shore towards Halifax Shipyards. In nine of the eleven months the reference values were reached within a short distance from the point of discharge in the bottom stations.

In general, the worst condition of dispersion and removal was encountered during the month of October. The primary mechanism of reduction in this area was primarily the tidal and current activities resulting in contaminant removal. In nine of the eleven months of monitoring, the reference values were reached within the first 150 meters of the outfall area. The limits of 5.0 mg/L were reached and encountered in all months, but quickly returned to reference levels on most occasions.

Fig. 5.85 Surface profiles of the monthly average of
BOD(mg/l) at Duffus Street outfall,
September, 1984. $R = 2.6$ mg/l (reference value)

- 170 -

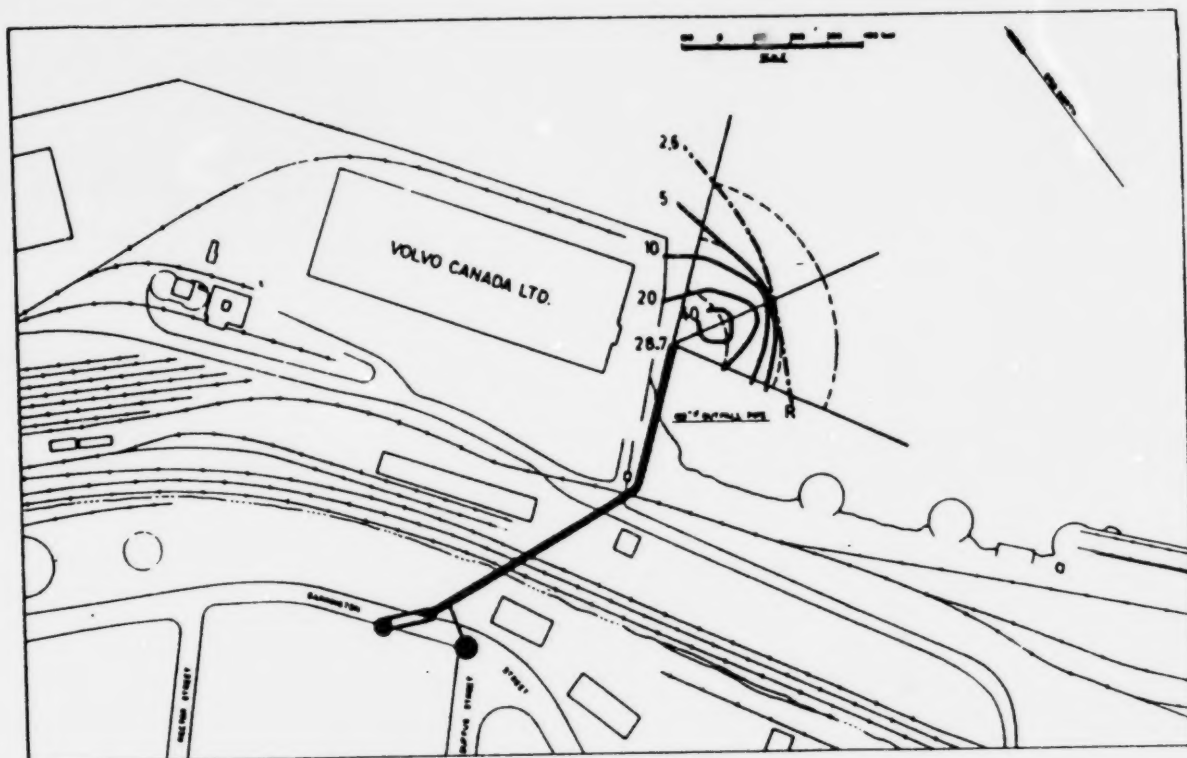


Fig. 5.86 Depth profiles of the monthly average of
BOD(mg/l) at Duffus Street outfall,
September, 1984. $R = 2.8$ mg/l (reference value)

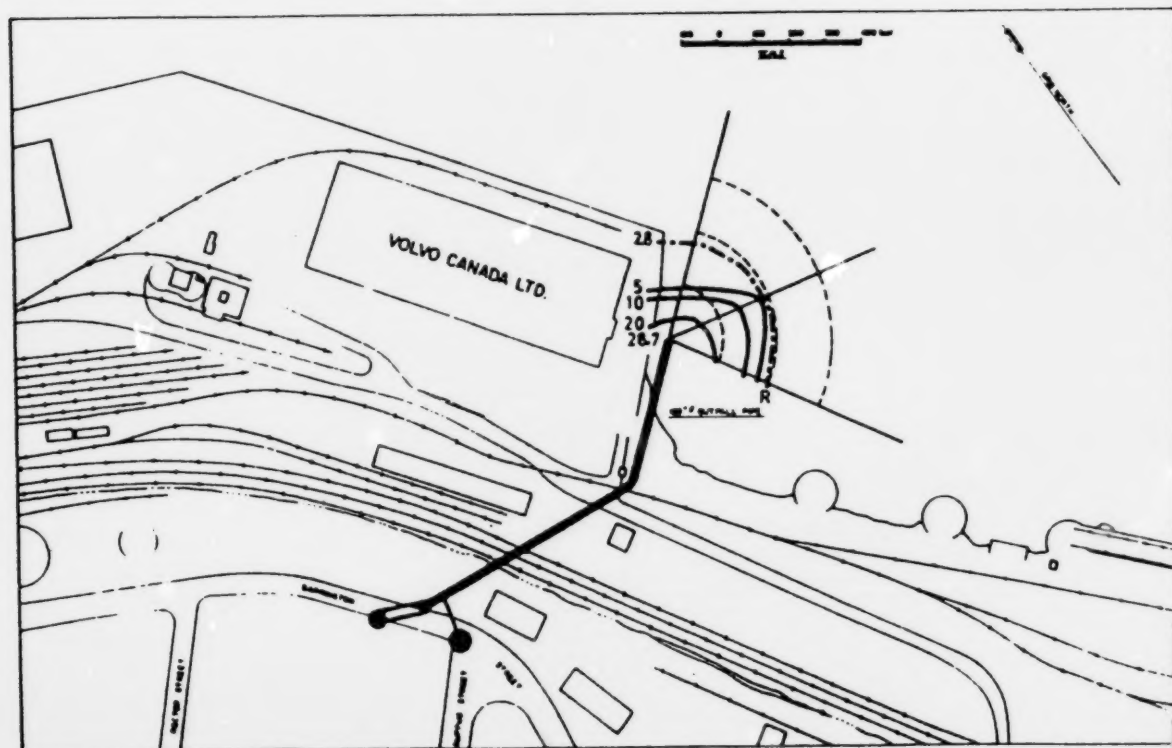


Fig. 5.87 Surface profiles or the monthly average of BOD(mg/l) at Duffus Street outfall, October, 1984. R= 2.6 mg/l(reference value)

- 171 -

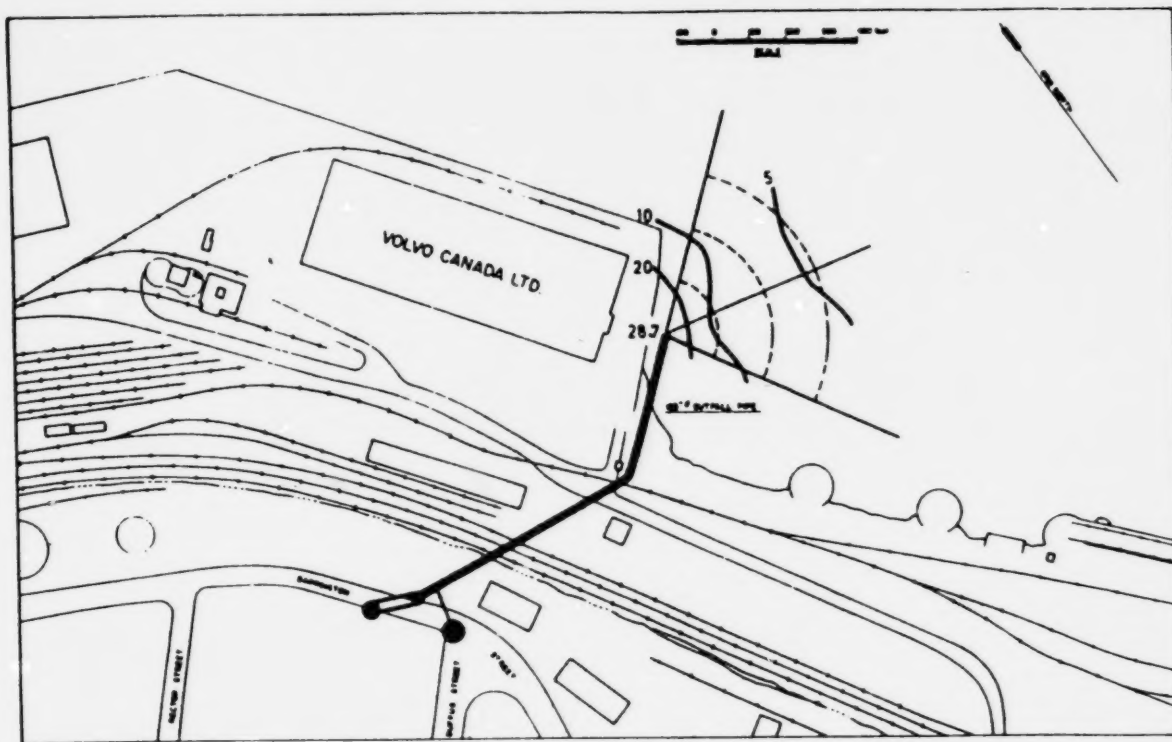


Fig. 5.88 Depth profiles of the monthly average of BOD(mg/l) at Duffus Street outfall, October, 1984. R= 2.8 mg/l(reference value)

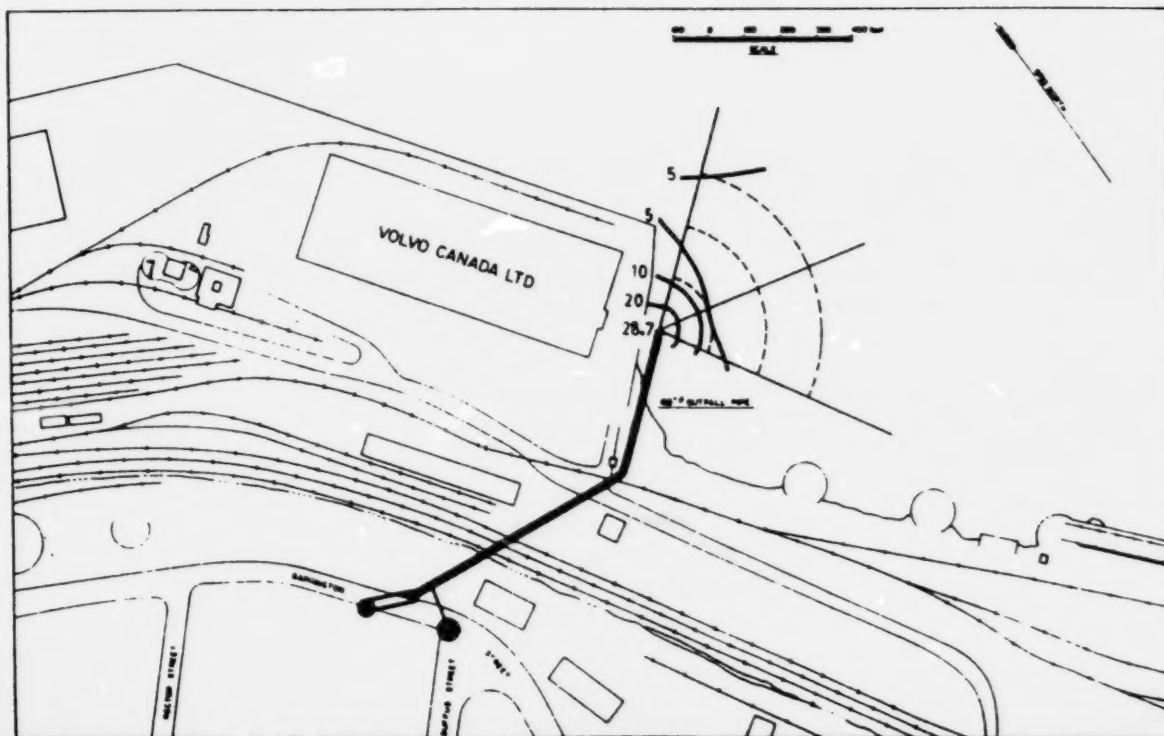


Fig. 5.89 Surface profiles of the monthly average of
BOD(mg/l) at Duffus Street outfall,
November , 1984 . R= 2.6 mg/l(reference value)

- 172 -

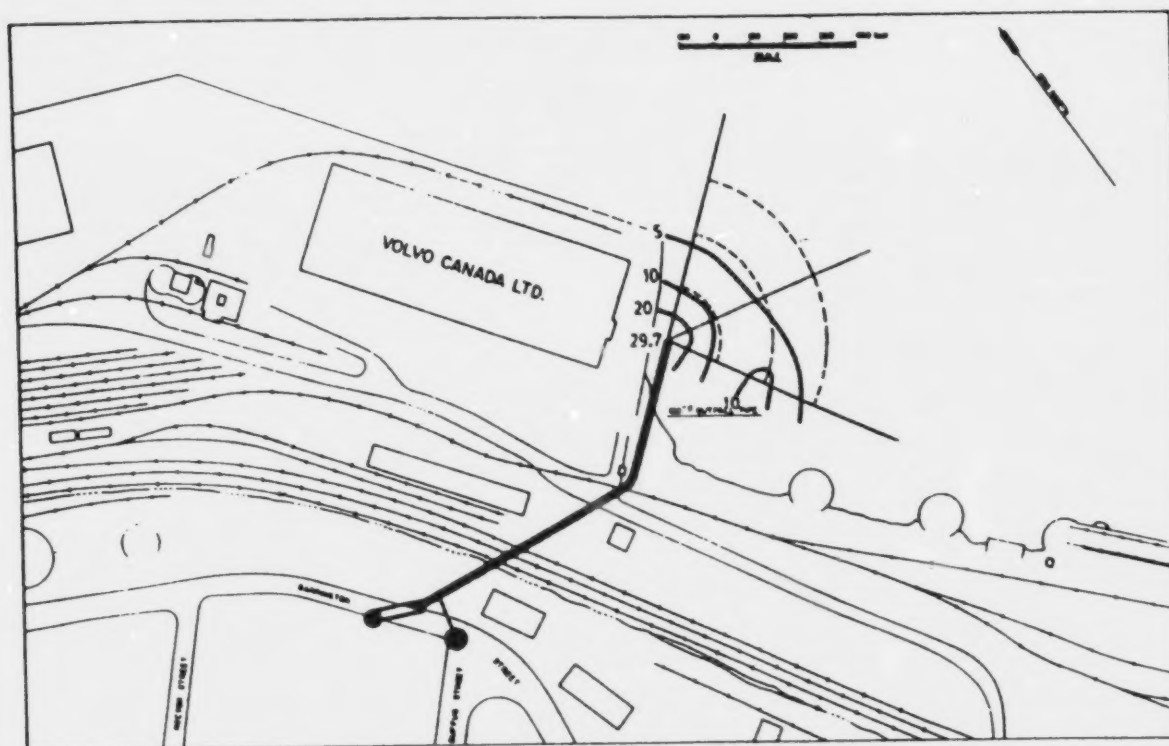


Fig. 5.90 Depth profiles of the monthly average of
BOD(mg/l) at Duffus Street outfall,
November , 1984 . R= 2.8 mg/l(reference value)

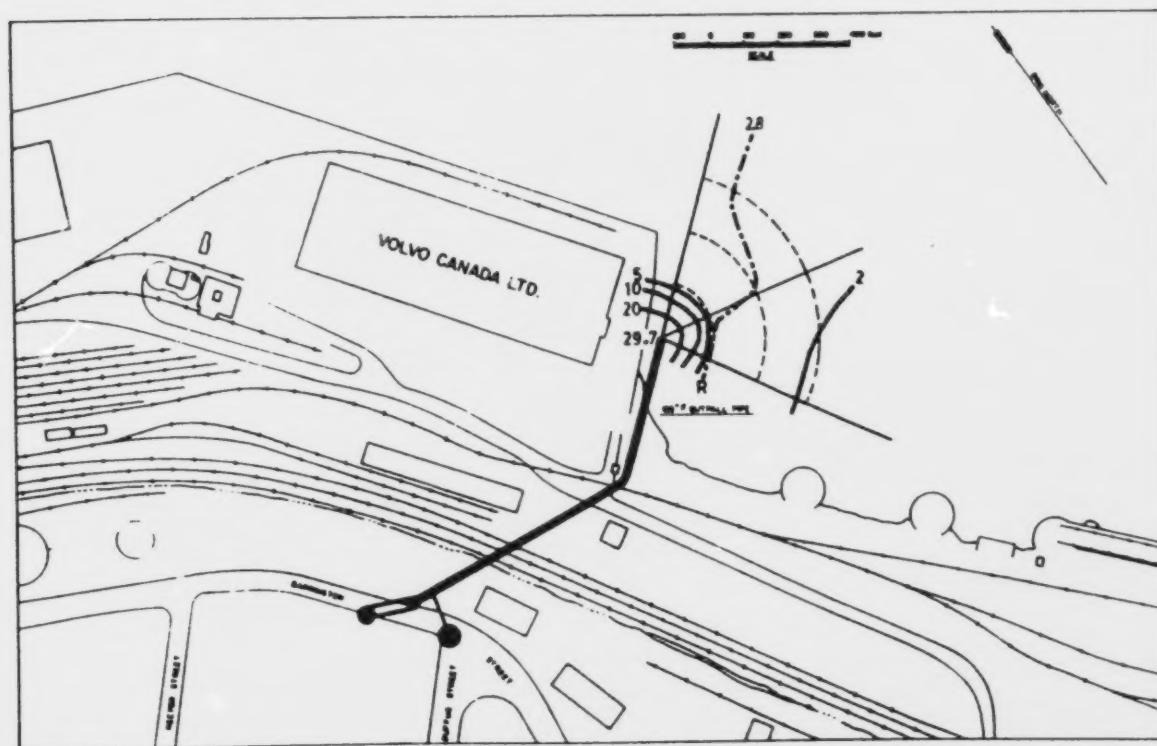


Fig. 5.91 Surface profiles of the monthly average of
BOD(mg/l) at Duffus Street outfall,
December , 1984 . $R = 2.6$ mg/l(reference value)

- 173 -

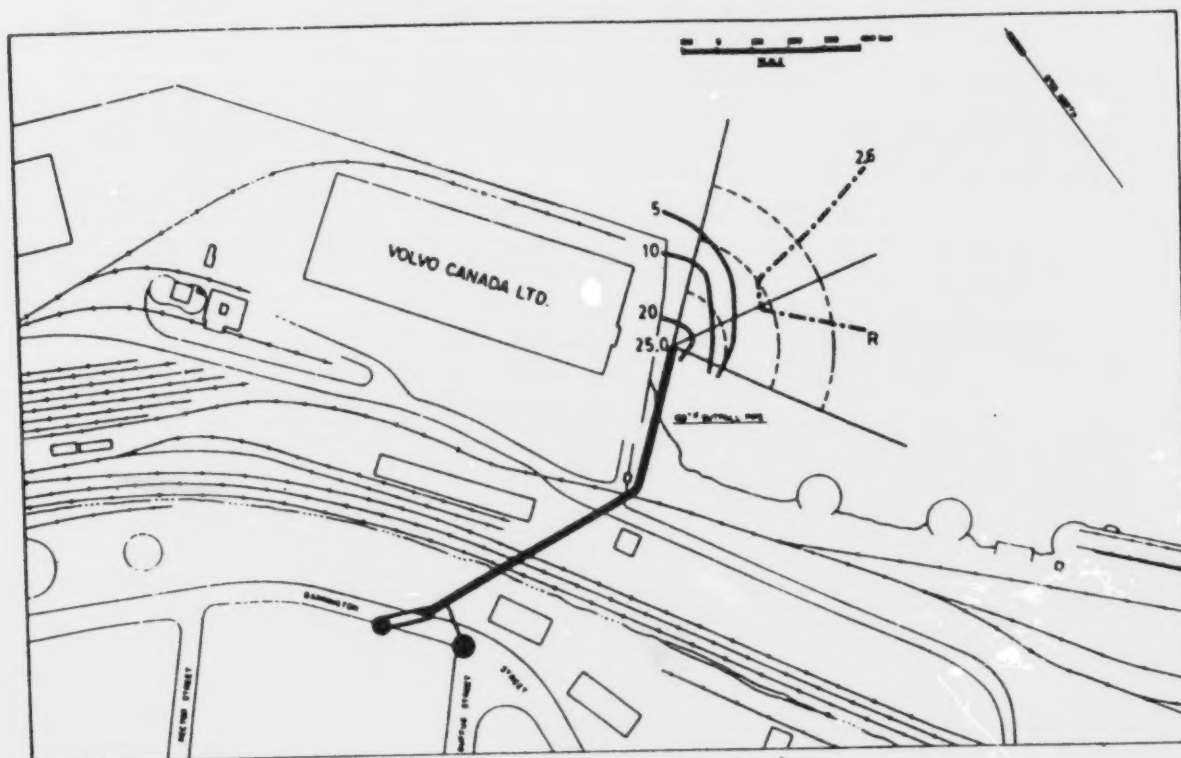


Fig. 5.92 Depth profiles of the monthly average of
BOD(mg/l) at Duffus Street outfall,
December , 1984 . $R = 2.8$ mg/l(reference value)

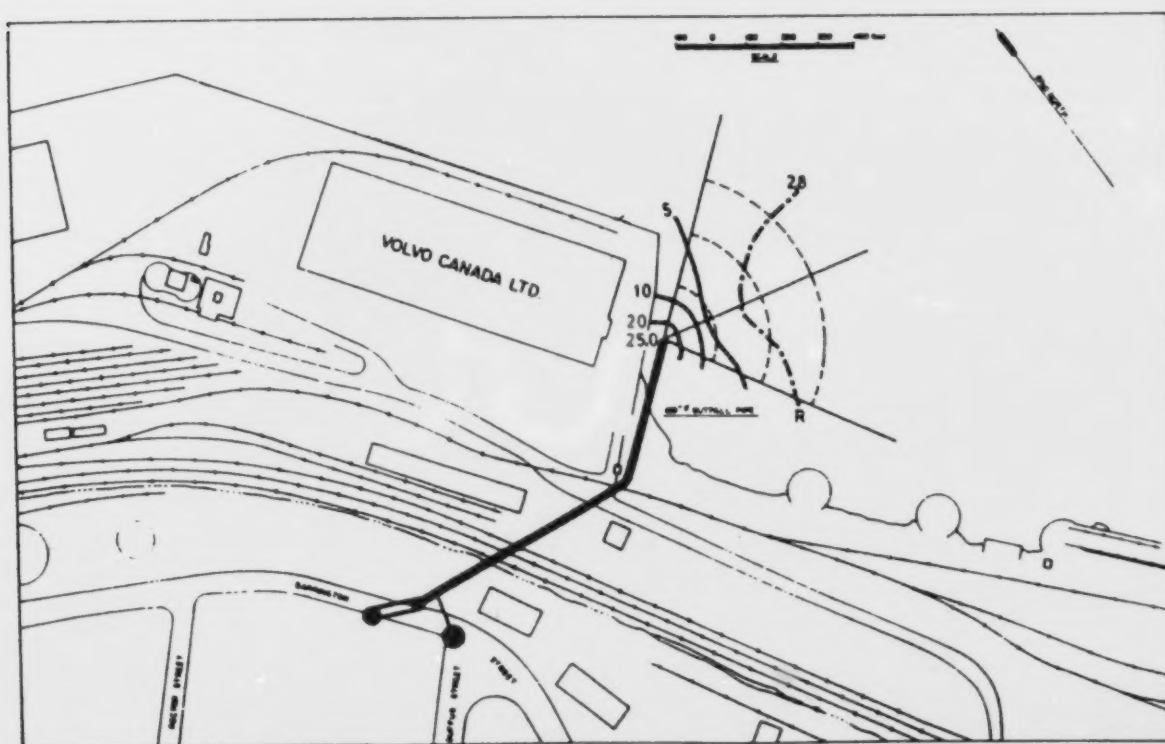


Fig. 5.93 Surface profiles of the monthly average of BOD(mg/l) at Duffus Street outfall, February, 1985. R= 2.6 mg/l(reference value)

- 174 -

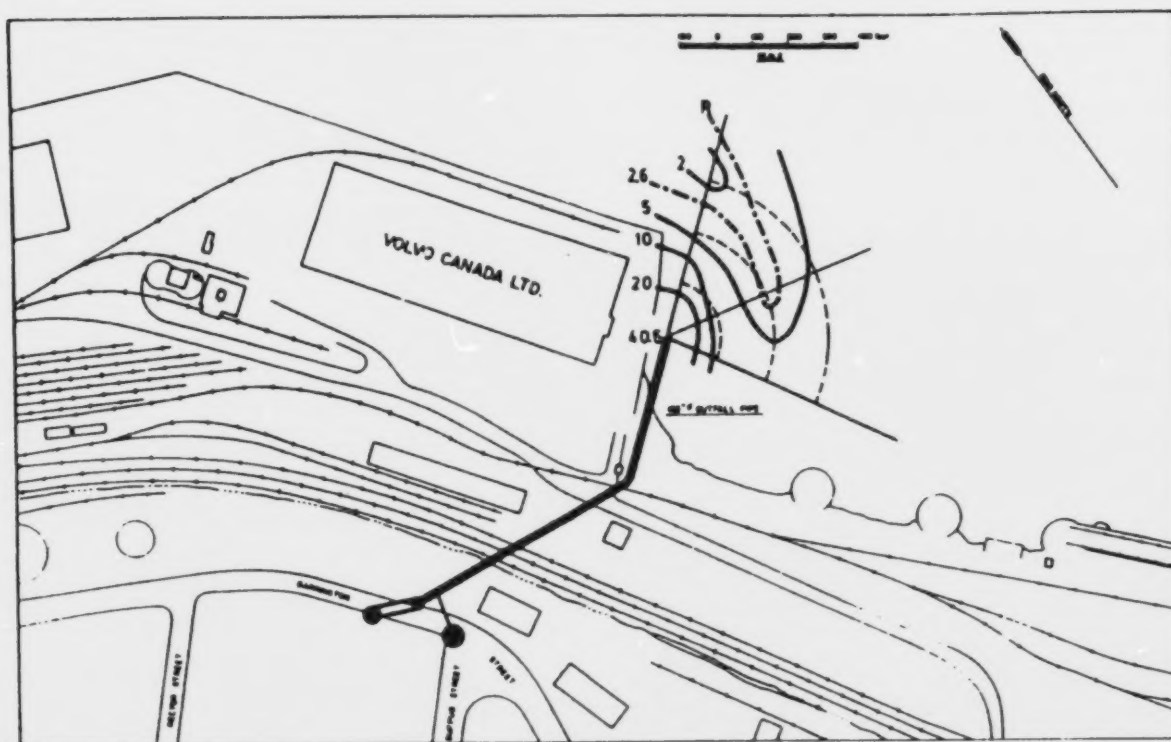


Fig. 5.94 Depth profiles of the monthly average of BOD(mg/l) at Duffus Street outfall, February, 1985. R= 1.3 mg/l(reference value)

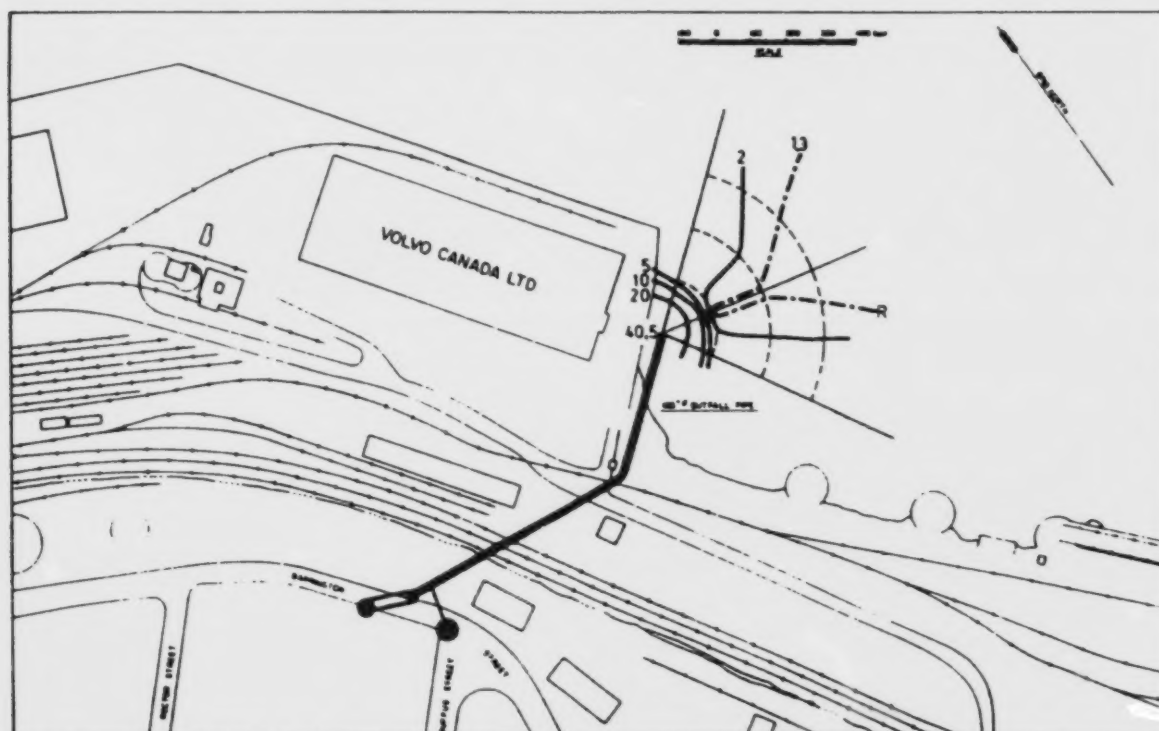


Fig. 5.95 Surface profiles of the monthly average of
BOD(mg/l) at Duffus Street outfall,
March, 1985. R= 2.6 mg/l(reference value)

- 175 -

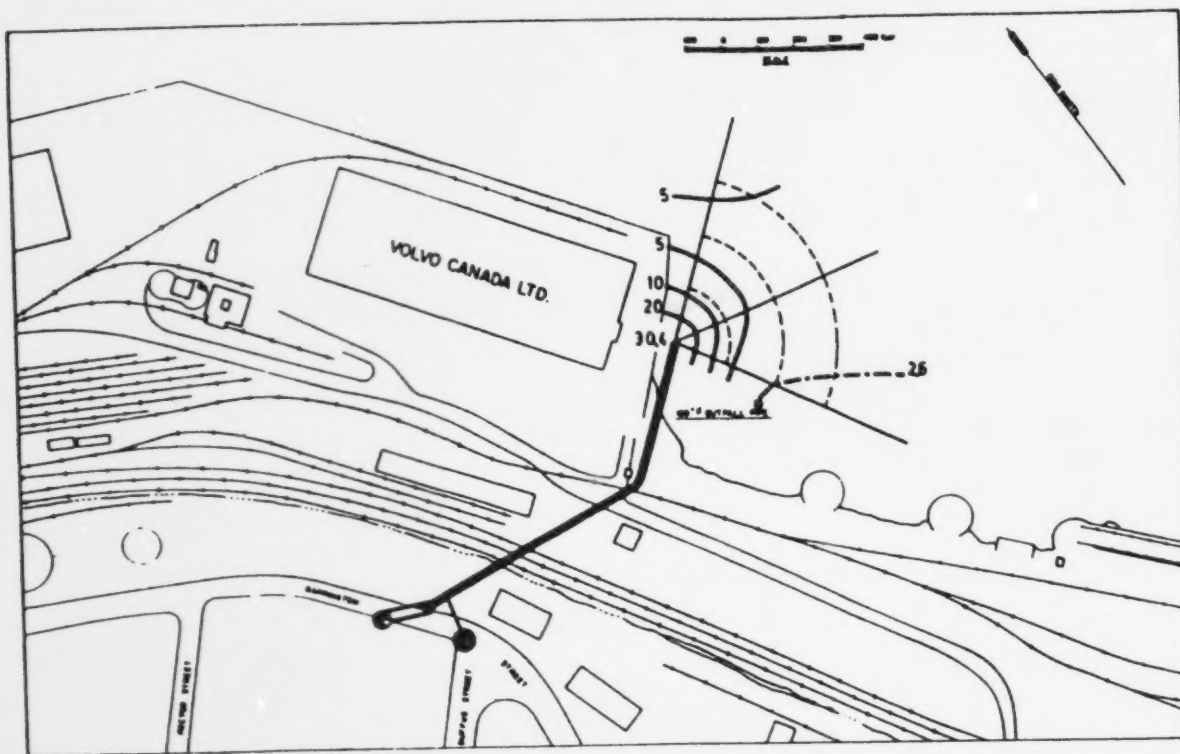


Fig. 5.96 Depth profiles of the monthly average of
BOD(mg/l) at Duffus Street outfall,
March, 1985. R= 1.3 mg/l(reference value)

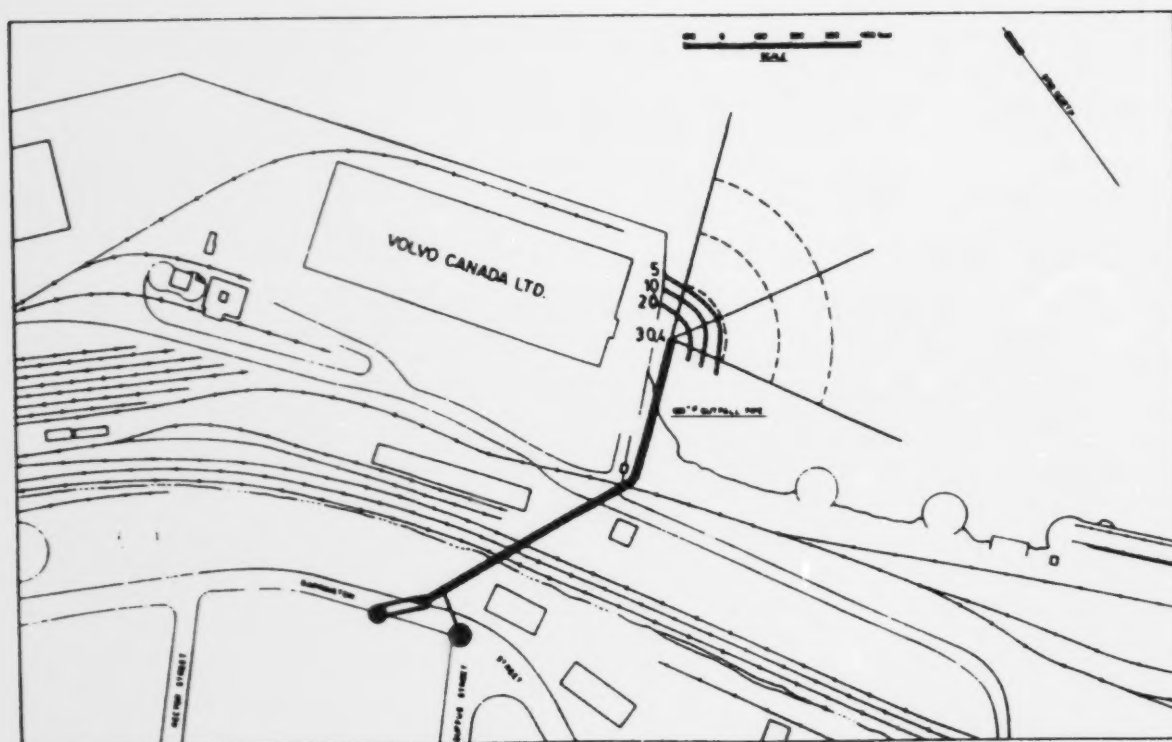


Fig. 5.97 Surface profiles of the monthly average of
BOD(mg/l) at Duffus Street outfall,
April , 1985 . $R = 2.1$ mg/l(reference value)

- 176 -

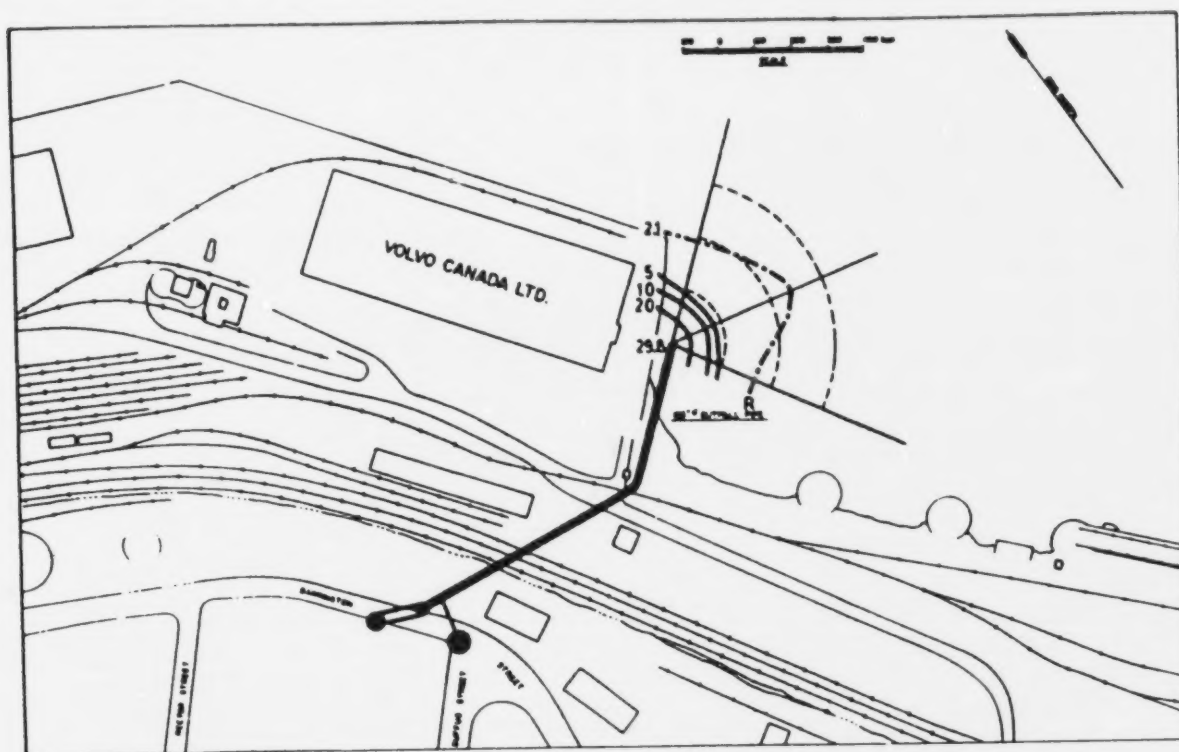


Fig. 5.98 Depth profiles of the monthly average of
BOD(mg/l) at Duffus Street outfall,
April , 1985 . $R = 1.7$ mg/l(reference value)

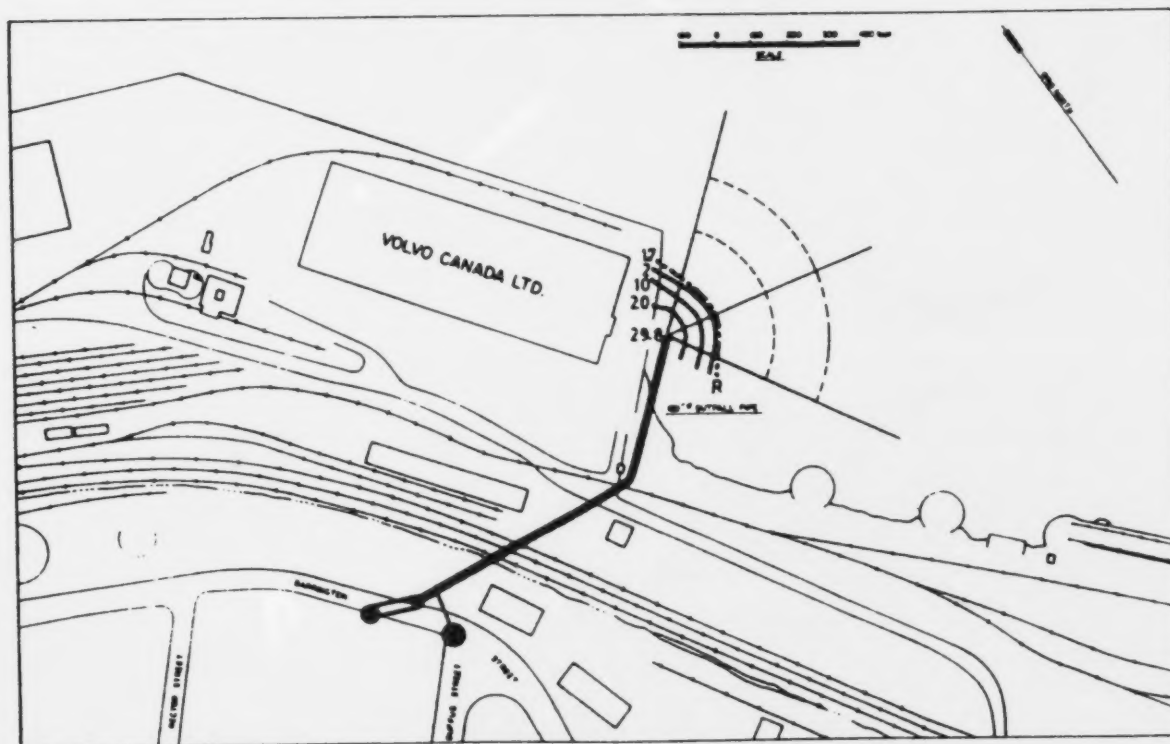


Fig. 5.99 Surface profiles of the monthly average of
BOD(mg/l) at Duffus Street outfall,
May , 1985 . R= 2.1 mg/l(reference value)

- 177 -

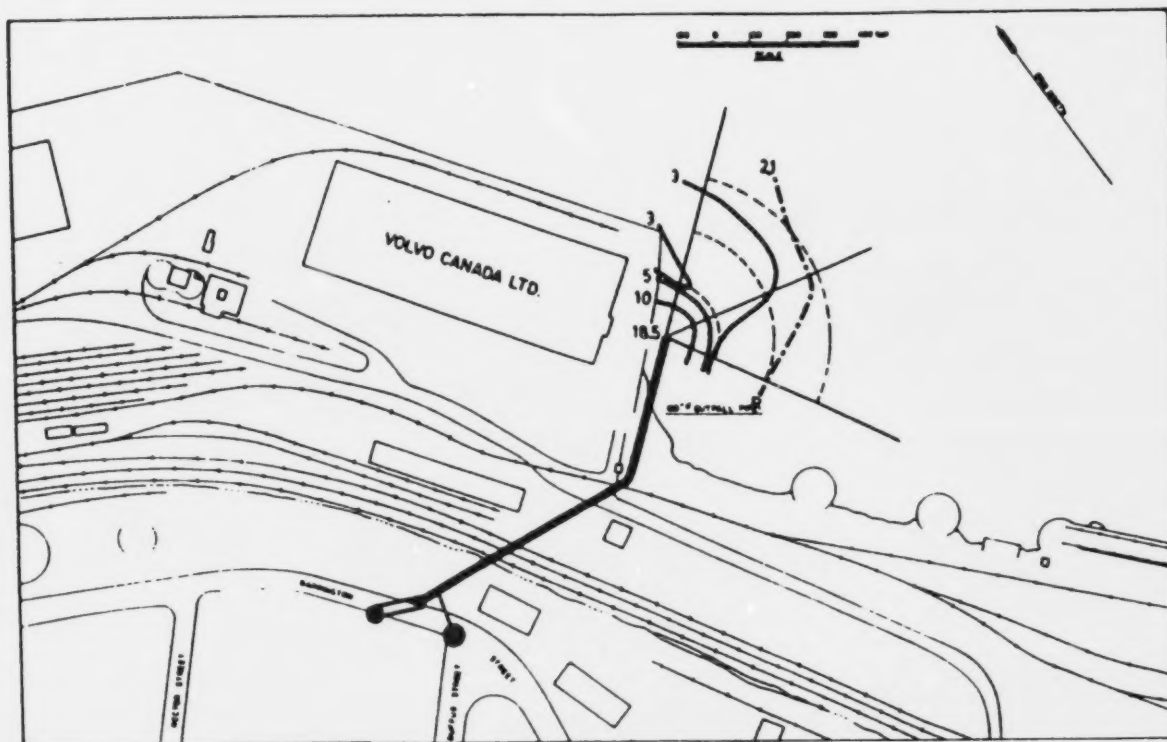


Fig. 5.100 Depth profiles of the monthly average of
BOD(mg/l) at Duffus Street outfall,
May , 1985 . R= 1.7 mg/l(reference value)

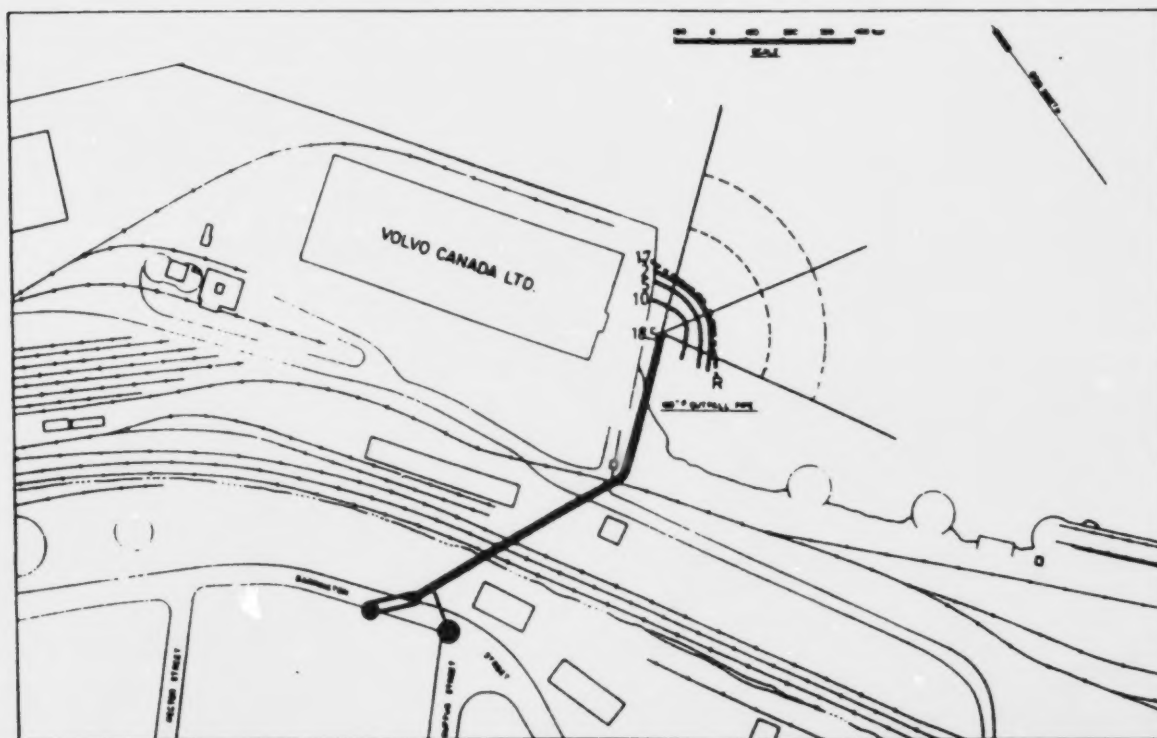


Fig. 5.101 Surface profiles of the monthly average of
BOD(mg/l) at Duffus Street outfall,
June , 1985 . $R = 2.1$ mg/l (reference value)

- 178 -

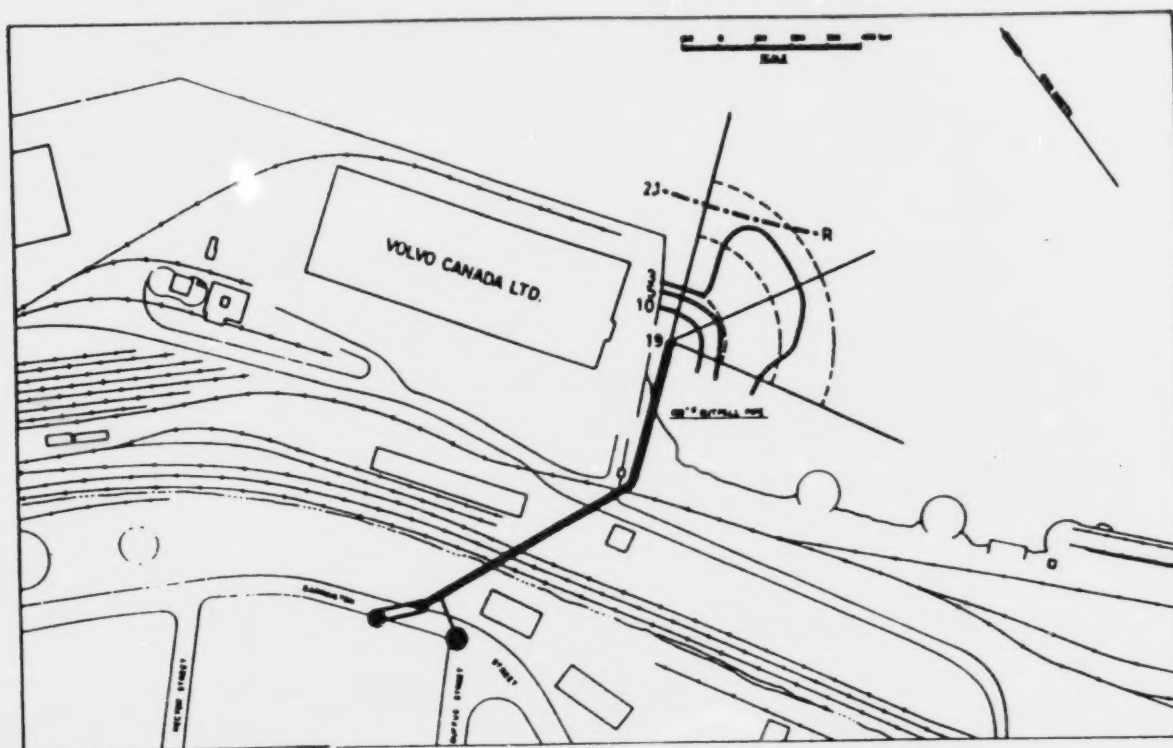


Fig. 5.102 Depth profiles of the monthly average of
BOD(mg/l) at Duffus Street outfall,
June , 1985 . $R = 1.7$ mg/l (reference value)

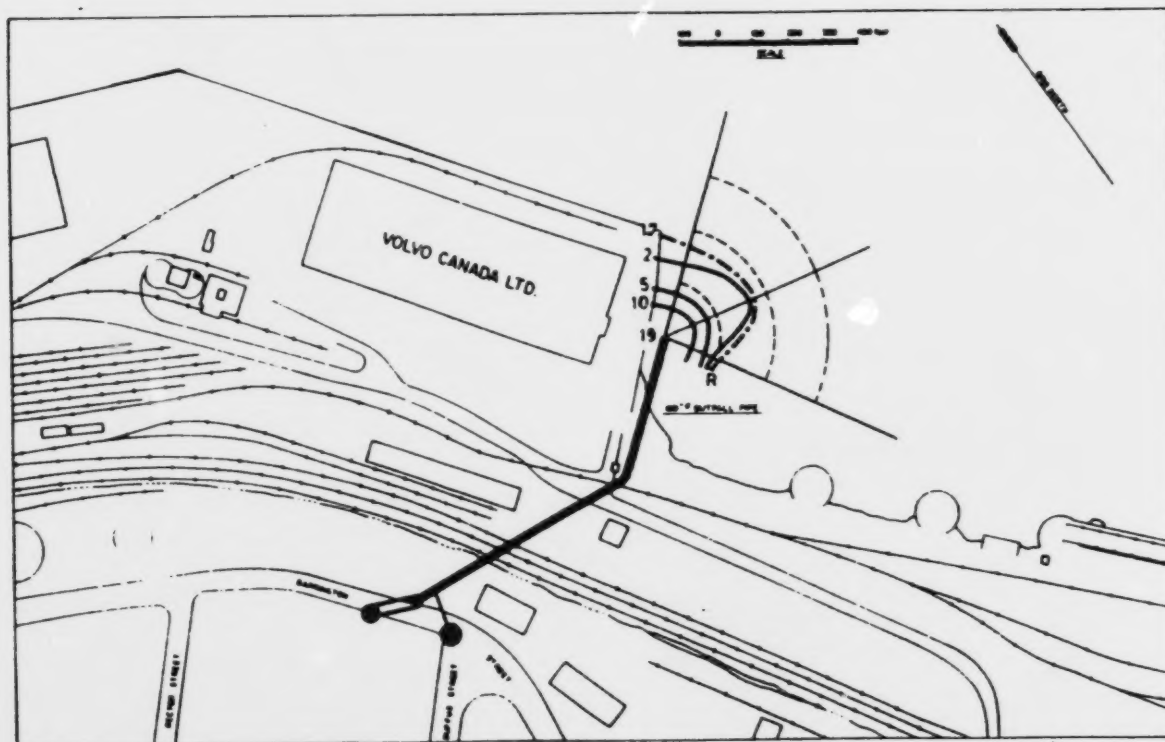


Fig. 5.103 Surface profiles of the monthly average of
BOD(mg/l) at Duffus Street outfall,
July , 1985 , R= 3.8 mg/l(reference value)

- 179 -

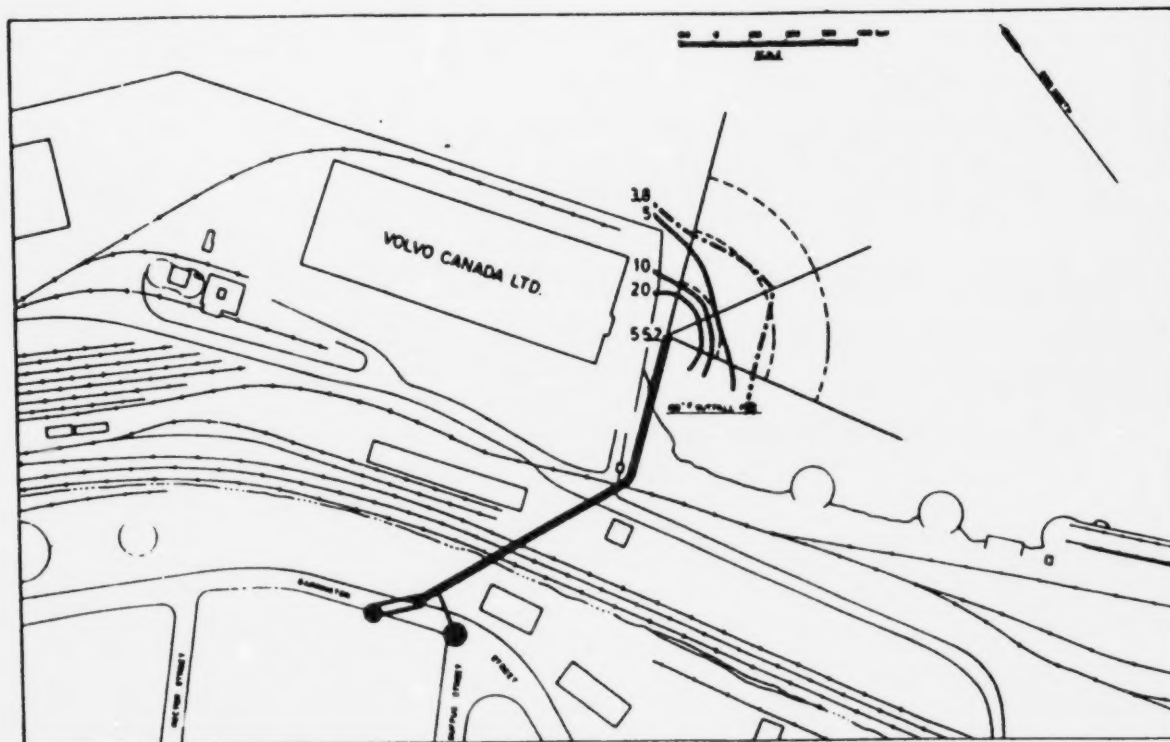


Fig. 5.104 Depth profiles of the monthly average of
BOD(mg/l) at Duffus Street outfall,
July , 1985 , R= 2.8 mg/l(reference value)

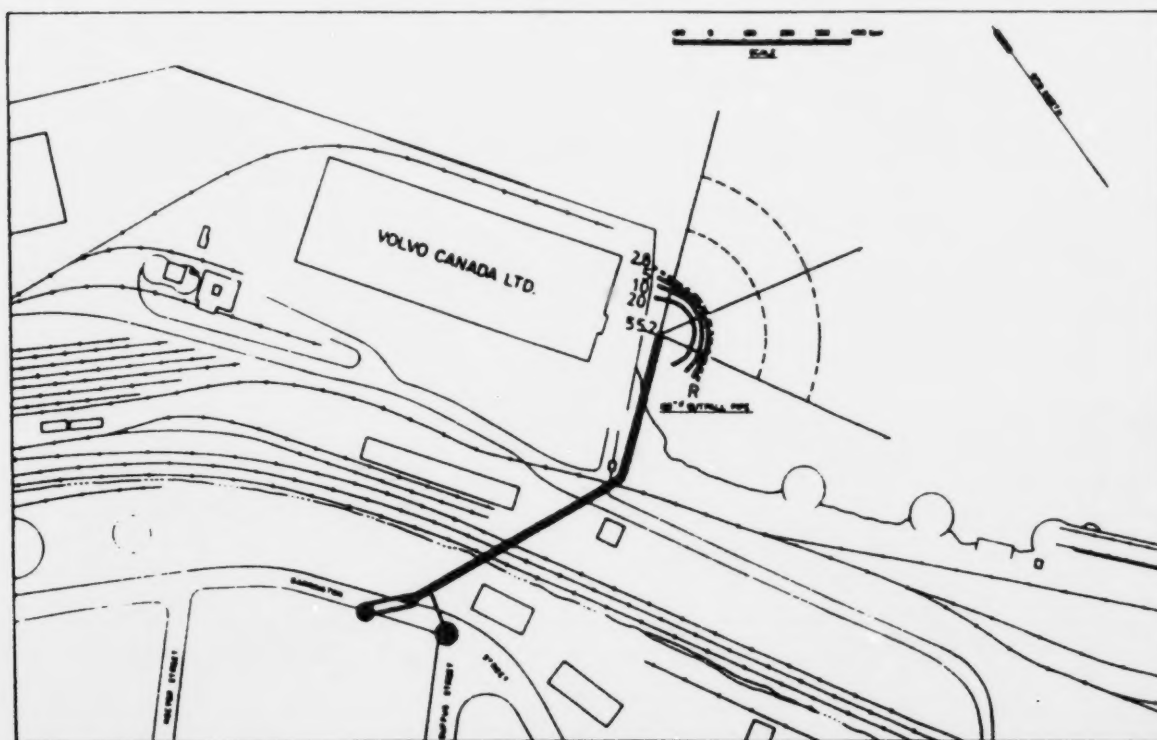


Fig. 5.105 Surface profiles of the monthly average of
BOD(mg/l) at Duffus Street outfall,
August , 1985 .R= 3.8 mg/l(reference value)

- 180 -

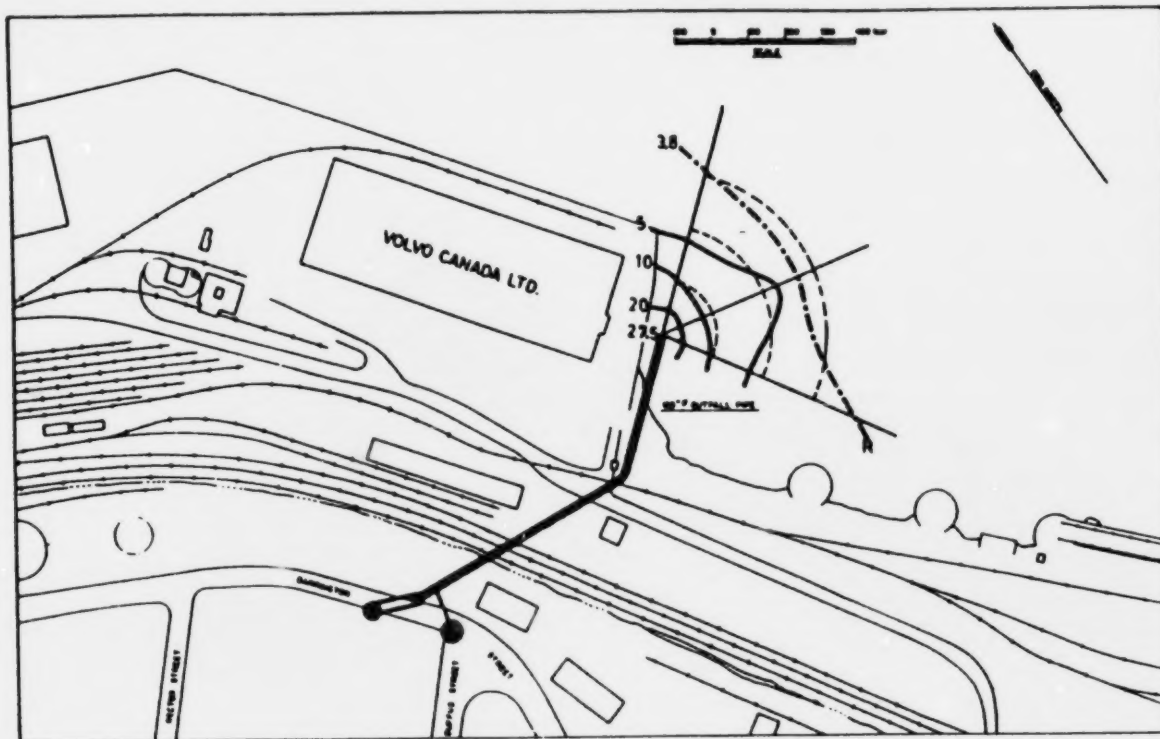
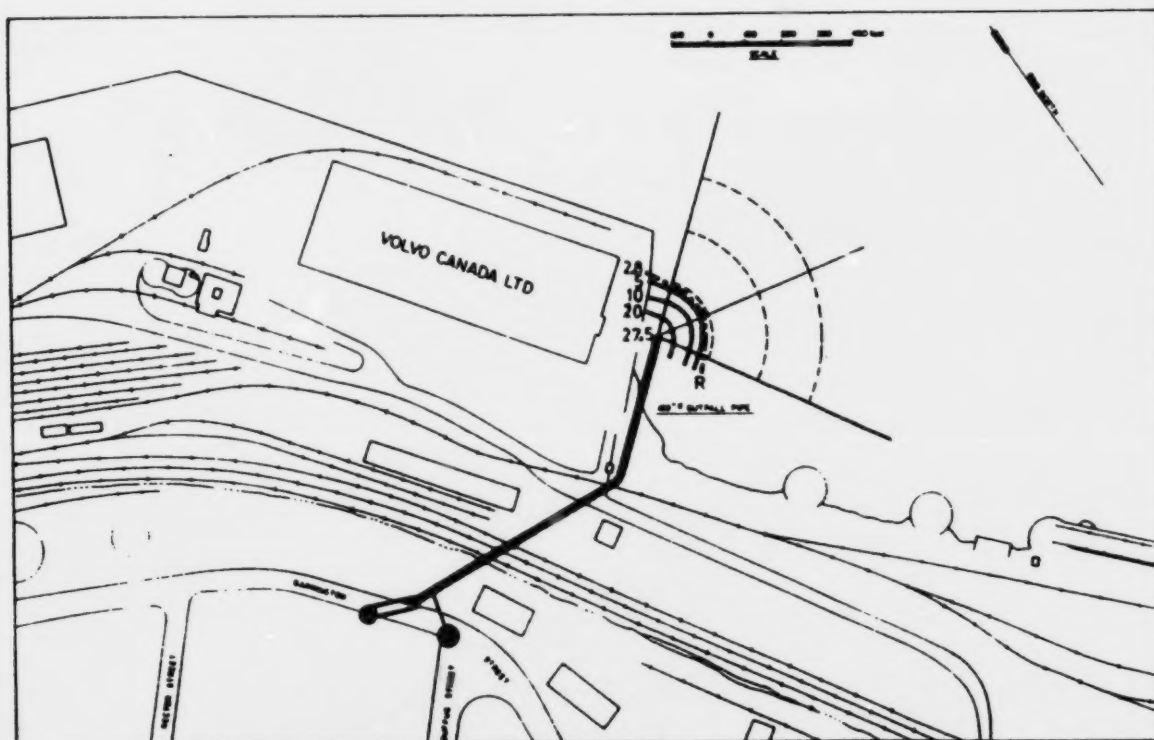


Fig. 5.106 Depth profiles of the monthly average of
BOD(mg/l) at Duffus Street outfall,
August , 1985 .R= 2.8 mg/l(reference value)



An assessment of the BOD values would indicate the presence of various degrees of dilution, dispersion and possible assimilation were present. At every site, the contaminants had greater concentrations on the surface than the bottom. In some instances, the percent reduction also followed this pattern of behaviour. In addition, the surface BOD values of the outfalls were higher than those observed in the reference sites, while the bottom waters had similar values as those of the references, indicating a major concentration of the contaminants in the overriding freshwater sewage. During spring the contaminants appeared to dissipate at a expected faster rate considering the elevated biological activities in this season. There was a certain degree of contaminant pooling in Duffus Street and Dartmouth Cove plume waters. The values presented by N.S.D.O.E. in 1976 appeared to be similar or lower than the values noted in this report. When considering only the BOD data as the representative parameter, beyond the plume waters of each outfall, the concentrations are within the recommended levels for fishing and swimming.

5.1.8 Analysis and Interpretation of the Suspended Solids Data

All the contents of sewage, apart from the water, are known as solids. Solids are categorized as settleable, suspended and dissolved. Small sized debris, such as personal hygiene items, could also be included. In this subsection the results of the suspended solid components of the plume waters (seawater and sewage) will be analyzed. Photoplate 8 depicts colouration and amounts of solids filtered from Tufts Cove, Duffus Street and the reference stations during the summer months.

Solids in the plume waters carry a variety of components that originate from wastewater, including metals, natural and synthetic organic compounds, bacteria and viruses, sands, silts and salts plus others. Moreover, the receiving seawater contains river borne detritus, various other waste discharges, atmospheric fallouts, chemical reaction residues, resuspended sediment particles and ocean related microorganisms and plants.

The Sackville River sediment is primarily deposited in the Basin, but due to the activity of the tides, currents and mean currents, the suspended and soluble components could reach the Harbour. At the same time, the solids discharged into Halifax Harbour could be deposited in the Basin by the landward movement of the currents.

Solids from other wastewater sources are: the discharges of the process and cooling waters of industry and establishments, as well as from old dumps around the Harbour. Wastewater discharges and solids transported by the Sackville River are also other contributing sources.

Atmospheric fallout is another component of solids in seawater. These solids are either from natural sources such as dust and devoided vegetation from the surrounding area, or volcanic ashes in the atmosphere. The fallouts from industrial and agricultural sources such as flyash from burning coal (NSPC); aerosols of industrial minerals (Gypsum Industry), lead aerosols from internal combustion engines and material used on wooded and agricultural lands are also other components.

Tidal activity, currents, waves and surges resuspend some of the solids near the bottom. This is a significant mechanism of resuspension in shallow waters and a source of elevated suspended solids in the waters of the Harbour and outfall areas.

The plume waters contain large amounts of sea origin microorganisms that thrive on the suspended organics. A combination of the marine biota plus the bacteria and viruses of the sewage, constitutes another portion of the suspended matters.

Urban storm runoff contains sand, silt, salt and plant remains, bird and animal droppings that are finely crushed. A portion of these solids have sizes greater than 0.45 microns (filter pore size) and are components of suspended solids, while the finer particles are not captured by filtration of the wastewater. The quantity of the solids in the runoff is a function of the duration and strength of the storm, as well as the conditions, percentage permeability of the tributary area and the season.

Sewage contains a variable quantity of suspended solids from different sources. The characteristics and amount of solids is a function of the land use activities, population and topography of the tributary area.

A typical suspended solid concentration in the open ocean is 0.1 to 1.0 mg/L, while the coastal waters (within 100 km of the shoreline) contain 1.0 to 30.0 mg/L (Conomos 1968, Manhein et al 1970). From the total suspended solids near the shore, an average of 20-40% are from organic origin (Manhein et al 1970).

Presence of suspended solids from any source, limits the light penetration and decreases the primary productivity resulting from photosynthesis. In the fishing grounds, a high level of suspended and settleable solids disrupts the benthic life and the bottom dwellers feeding grounds. Biodegradable suspended solids exert an oxygen demand on the water column and further resuspension of settled solids results in further dissolved oxygen depletion. Moreover, resuspension of the toxic content of solids such as heavy metals, occurs as a result of turbulent activities, which impacts the water column adversely. The best example of the resuspension of settled solids are presented in photoplates 10 and 11.

Solids emanating from the outfall pipes are visible in the surface waters of the plume areas. There is also sludge build up in these areas. The visible turbidity is aesthetically unappealing and draws attention to the plume waters; while the sludge deposits are a possible hindrance to the aquatic life. Also, the organic matter depletes the oxygen content of the water column.

Tufts Cove

Monthly averages and the respective statistical analysis of the daily data are presented in Table B.3.1 of Appendix B. Figures 5.107 to 5.113 contain the graphic illustration of the monthly data.

The range of suspended solid concentration discharged from Tufts Cove was 21.4 to 177.0 mg/L, while the range for the respective manhole samples was 29.9 to 172.0 mg/L. Percent accumulation of the solids was 150% and percent

reduction due to dilution was 71% from the manhole to the point of discharge (Table 5-16); indicating a low level of reduction of suspended solids from the water column. This condition was a result of a high input to removal ratio as well as low initial dilution rate due to current inactivity and shallowness of the cove.

In the shallow stations of the cove (2, 3 and 4) the average suspended solids of the bottom waters were lower than the surface waters. This condition was more prevalent in the fall, than winter and spring, with a marked variation. The calmness of this section of the Cove would allow better settling conditions.

Within the other stations there was a more uniform distribution of suspended solids on the surface in late winter and early spring. At the same time, percent reduction of the suspended solids was higher on the bottom stations (Table 5-11). There was more dilution and dispersion of surface suspended matter in the late spring and early summer months than in other months. A wide range of values was present in the Cove, for instance, in April, minimum and maximum values observed were 20.6 and 1272.7 mg/L. This wide range of variation was also apparent between the discharges during the fall and summer months, which could be a result of higher assimilation of the solids. The peak monthly averages were in the winter, and the lower values were observed in the summer indicating seasonal dependency for the solid concentrations.

Generally, the percent reduction due to dilution appear to be low, but the values reduced to a maximum of 70.0 mg/L within 150 meters from the point of discharge. The reference values were lower than those present in the cove with exception in summer. It is evident that Tufts Cove receives a substantial amount of suspended matter, but there has been a decrease in the manhole values, since the last sampling by N.S.D.O.E. 1976. The N.S.D.O.E. report indicated a range of 101.0 to 782.0 mg/L for the manhole. It is evident that on a monthly basis, suspended solid values reach the critical recommended value and on a daily basis, the waters contain more suspended matter than considered optimum for benthic life. These values were also greater than those observed outside the Harbour, except for the summer months.

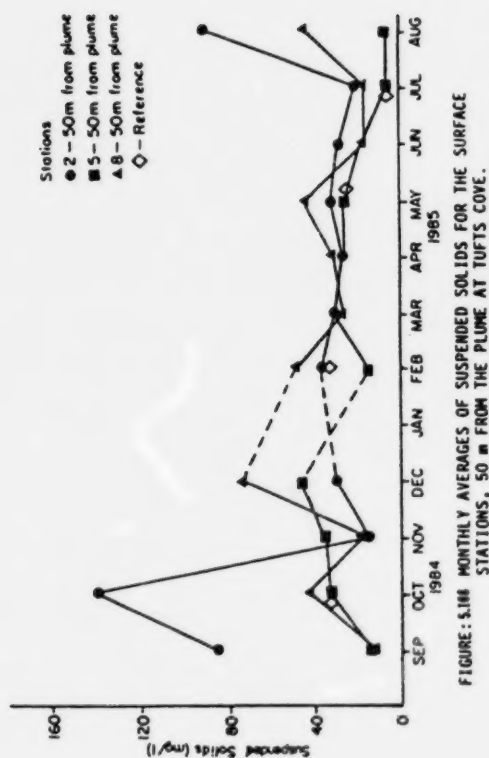


FIGURE 1.188 MONTHLY AVERAGES OF SUSPENDED SOLIDS FOR THE SURFACE STATIONS, 50 m FROM THE PLUME AT TUFTS COVE.

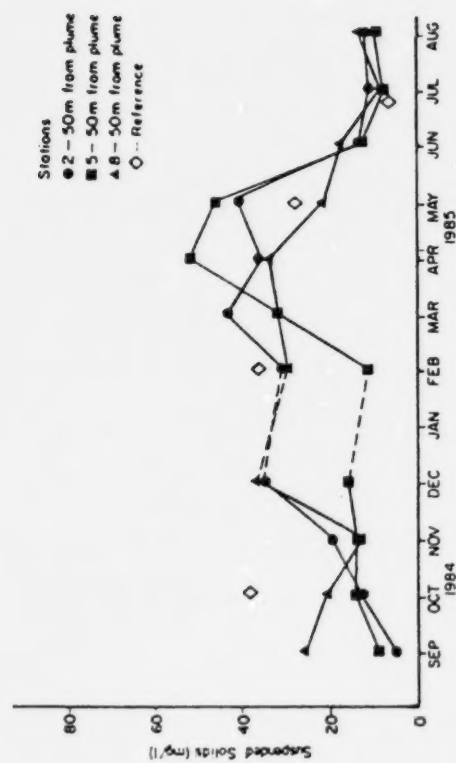


FIGURE 1.189 MONTHLY AVERAGES OF SUSPENDED SOLIDS FOR THE DEPTH STATIONS, 50 m FROM THE PLUME AT TUFTS COVE.

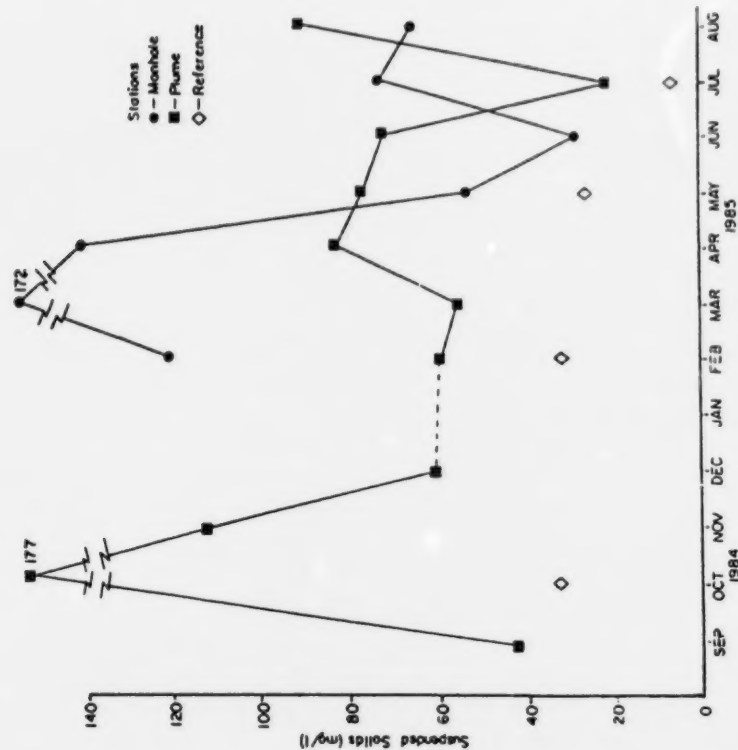


FIGURE 1.187 MONTHLY AVERAGES OF SUSPENDED SOLIDS FOR THE MANHOLE, PLUME AND REFERENCES AT TUFTS COVE, 1985.

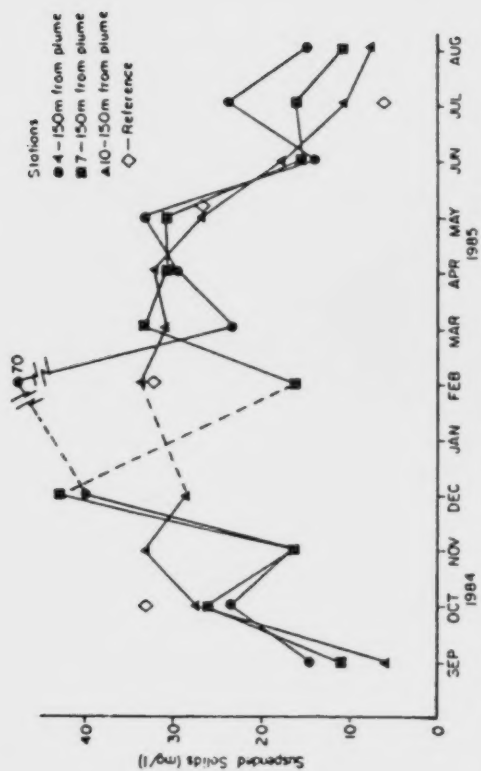


FIGURE: 5.112 MONTHLY AVERAGES OF SUSPENDED SOLIDS FOR THE SURFACE STATIONS, 150 m FROM THE PLUME AT TUFTS COVE.

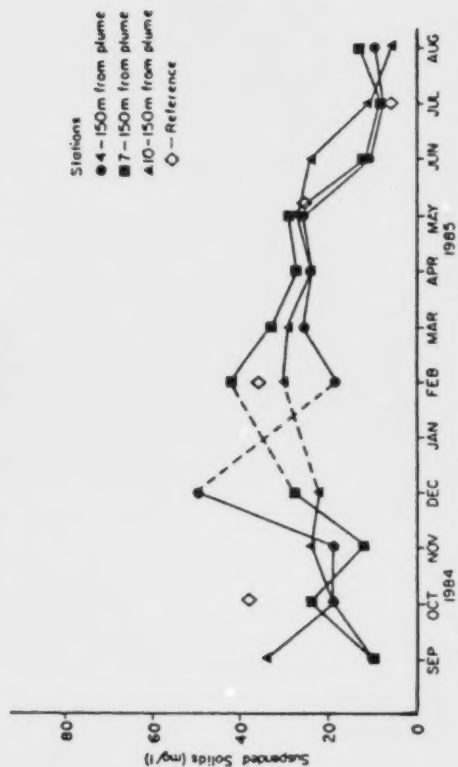


FIGURE: 5.113 MONTHLY AVERAGES OF SUSPENDED SOLIDS FOR THE DEPTH STATIONS, 150 m FROM THE PLUME AT TUFTS COVE.

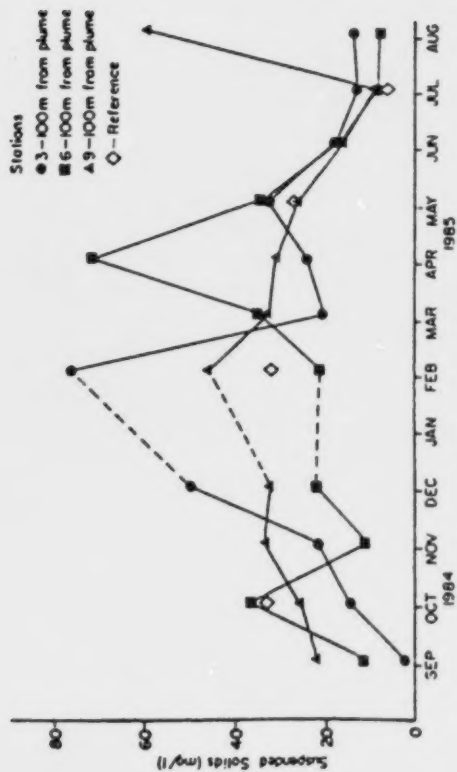


FIGURE: 5.110 MONTHLY AVERAGES OF SUSPENDED SOLIDS FOR THE SURFACE STATIONS, 100 m FROM THE PLUME AT TUFTS COVE.

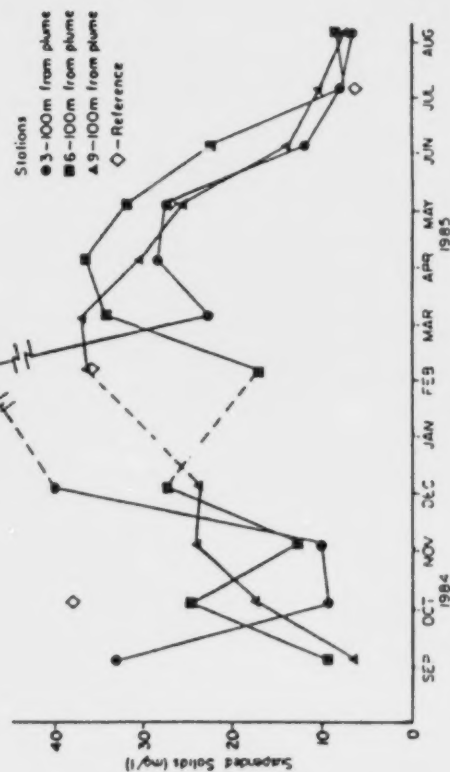


FIGURE: 5.111 MONTHLY AVERAGES OF SUSPENDED SOLIDS FOR THE DEPTH STATIONS, 100 m FROM THE PLUME AT TUFTS COVE.

Table 5-11 Percent reduction of Suspended Solids in comparison with the discharge point or the manhole at Tufts Cove outfall, due to dispersion, assimilation and removal by tides and currents.

Month	Source Strength	% reduction from the source at the 50 meter stations	% reduction between the 50 and the 100 meter stations	% reduction from the source at the 100 meter stations	% reduction between the 100 and 150 meter stations	% reduction from the source at the 150 meter stations
September 1984	42.0*	12.7 S 67.9 B	60.0 S -7.8 B	72.2 S 61.1 B	2.8 S -4.4 B	75.0 S 56.7 B
October	177.0*	59.7 S 90.7 B	20.8 S -0.3 B	85.5 S 90.4 B	0.0 S -2.4 B	85.5 B 88.0 B
November	111.0*	80.0 S 86.2 B	0.5 S -0.2 B	80.5 S 86.0 B	-0.3 S -2.5 B	80.2 S 83.5 B
December	60.5*	16.5 S 51.8 B	26.2 S -1.6 B	42.7 S 50.2 B	-5.0 S -5.6 B	37.2 S 44.6 B
February 1985	120.8	80.7 S 80.0 B	-21.0 S -27.6 B	59.7 S 52.4 B	7.0 S 22.4 B	66.9 S 82.8 B
March	172.0	82.8 S 79.3 B	0.5 S 2.7 B	83.3 S 82.0 B	-0.1 S 0.8 B	83.2 S 82.8 B
April	141.0	79.7 S 71.4 B	-9.9 S 6.2 B	69.8 S 77.6 B	8.4 S 4.4 B	78.2 S 82.0 B
May	76.9*	54.9 S 33.8 B	5.7 S 14.3 B	60.6 S 48.1 B	0.1 S 0.2 B	60.7 S 48.3 B
June	72.1*	76.5 S 49.4 B	0.1 S -4.5 B	76.6 S 44.9 B	1.6 S -4.8 B	78.2 S 40.1 B
July	73.0	81.6 S 76.8 B	5.0 S 11.7 B	86.6 S 88.5 B	-9.8 S -1.6 B	76.8 S 86.9 B
August	90.6	73.1 S 85.9 B	-3.4 S 6.1 B	69.7 S 92.0 B	19.2 S -3.2 B	88.9 S 88.8 B

* Plume
S = Surface
B = Bottom
- = assimilation

In the case of unusual discharges, an elevated level of suspended solids was not always present. For instance, on one occasion when the discharges were blue coloured and highly turbid, the settleable solids were more than the suspended solid component. However, as shown in photoplate 9 where the entirety of the Cove was black the transparency was 0.0%, then the suspended solids were extremely high. In other occasions of apparent spills when the sampling was done, elevated suspended matters were observed 100 - 150 meters from the discharge point.

To observe the behaviour of suspended solids, a bottle of the effluent was collected and kept under normal room temperature without any interference. The results are illustrated in photoplates 10 and 11. An initially 100% turbid black colour effluent produced a great amount of settled solids and the liquid component of the sample became viscous and still had a reasonably turbid character.

Duffus Street

Monthly averages and the statistical analysis of the daily data are presented in Table B.3.2 of Appendix B. The graphic representation are shown in figures 5.114 to 5.120.

Manhole values ranged from 27.0 to 100.8 mg/L, while the solids at the discharge point were in a range of 27.0 to 87.7 mg/L. A very low level of reduction due to dilution of 35.0% and addition of up to 90.0% had been observed at the manhole from the point of discharge; with lower dilution levels in spring than in summer (Table 5-16). This observation indicated that the strong jet of sewage through the outfall pipe decreased the initial dilution and was the reason for the presence of a greater amount of suspended solids in the surface waters.

High readings of solids within 150 meters of the outfall were observed in September and April, with substantially elevated concentrations in the spring months. More depressed values of suspended matter were present in the summer months. The range of values extracted from the daily results showed a maximum of 203.1 mg/L and a minimum of 2.0 mg/L. The daily results for each month

showed a wide range of variation except in March, April and May when their values were more uniform but higher. Suspended solid values were uniformly distributed and in every case the frequency of observations were skewed to the right of the mean value.

Except for the readings of March and May, the surface stations received more suspended solids than the bottom stations. This was due to freshwater sewage overriding the seawater. During fall, station 4 had more suspended solids than stations 2 and 3, which indicated a transportation of solids from other sources. In summer, there was a clear indication of solid removal from these stations. A comparison between the stations showed a marked movement of suspended matters towards Halifax Shipyard and along the shoreline.

The range of reduction of the suspended solids due to secondary dilution was 98.2% and a addition of 9.2%, this was observed in the bottom waters of the 50 and 150 meters stations, respectively; the maximum reductions were in summer and the minimum in fall (Table 5-12).

It is evident that the sewage jet of the Duffus Street outfall appears to hinder the dilution at the point of discharge. The freshwater density gradient causes floatation of the solids on the surface, up to 150 meters away. There was a net transportation of suspended matters to the shoreline from the outfall, which appeared to be governed by the currents. The suspended solid content of the reference sites were comparable to the waters of Duffus Street, except in spring where outfall waters contained more solids than the Harbour waters. Values of the solids present in these waters are within the recommended values after 150 meters of the plume area and improve towards the center of the Harbour. There appeared to be a decrease in suspended solids detected at the manhole, in comparison with the values reported by N.S.D.O.E. 1976 (72.0 to 461.0 mg/L, Mean = 171.43).

Dartmouth Cove

Monthly averages and analysis of daily data are presented in Table B.3.3 of Appendix B.

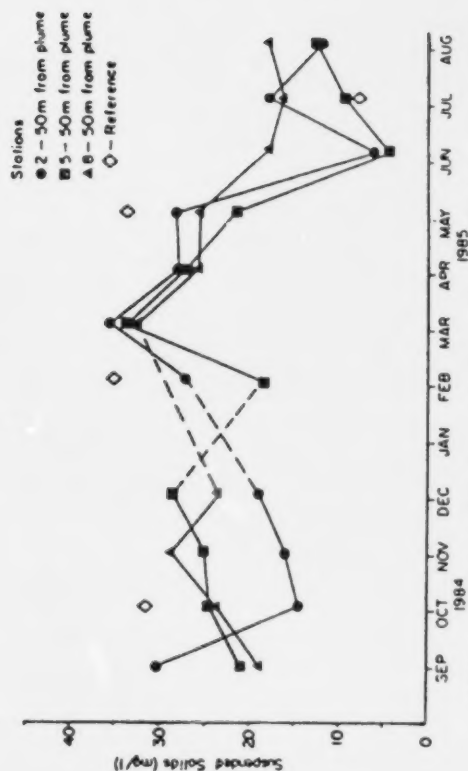


FIGURE 5.115 MONTHLY AVERAGES OF SUSPENDED SOLIDS FOR THE SURFACE STATIONS, 50 m FROM THE PLUME AT DUFFUS STREET.

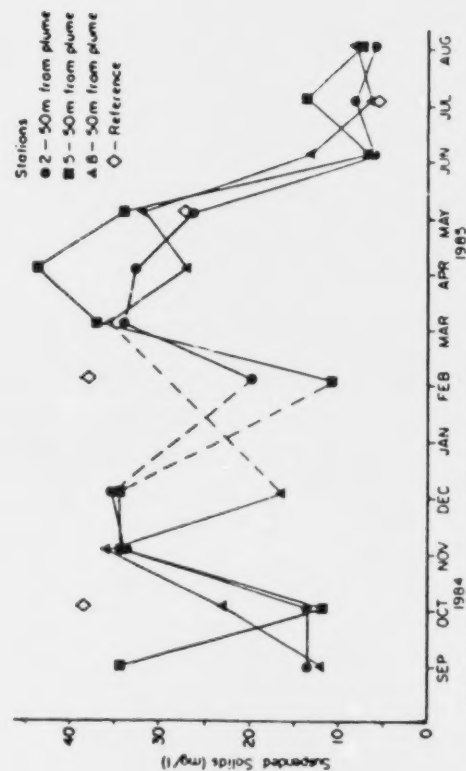


FIGURE 5.116 MONTHLY AVERAGES OF SUSPENDED SOLIDS FOR THE DEPTH STATIONS, 50 m FROM THE PLUME AT DUFFUS STREET.

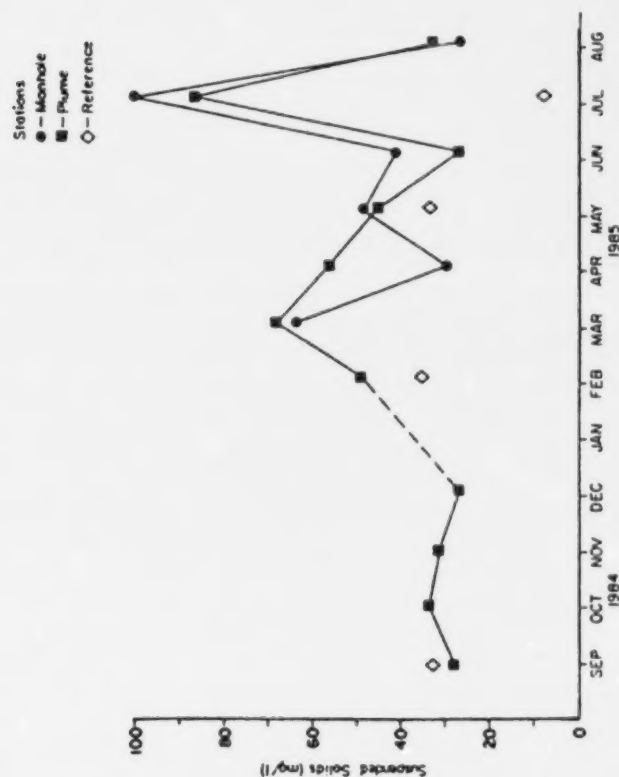


FIGURE 5.114 MONTHLY AVERAGES OF SUSPENDED SOLIDS FOR THE MANHOLE AND PLUME AT DUFFUS STREET.

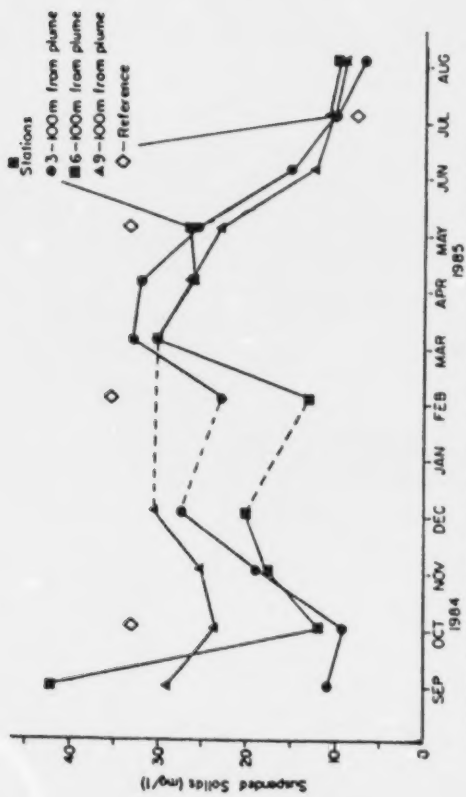


FIGURE: 5.117 MONTHLY AVERAGES OF SUSPENDED SOLIDS FOR THE SURFACE STATIONS, 100 m FROM THE PLUME AT DUFFUS STREET.

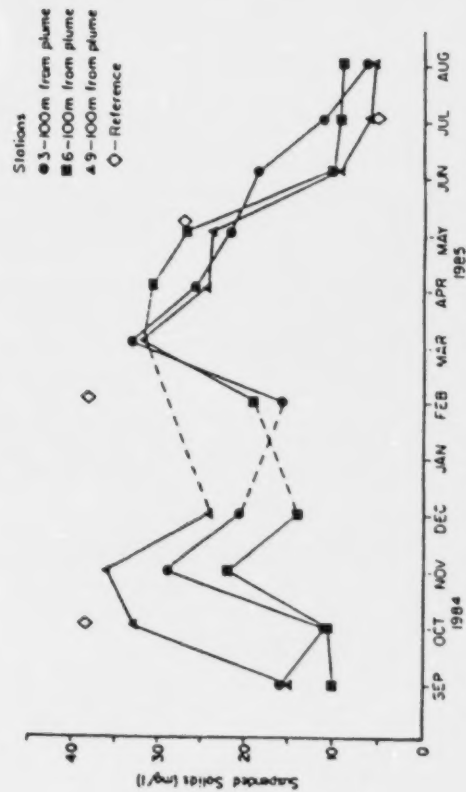


FIGURE: 5.118 MONTHLY AVERAGES OF SUSPENDED SOLIDS FOR THE DEPTH STATIONS, 100 m FROM THE PLUME AT DUFFUS STREET.

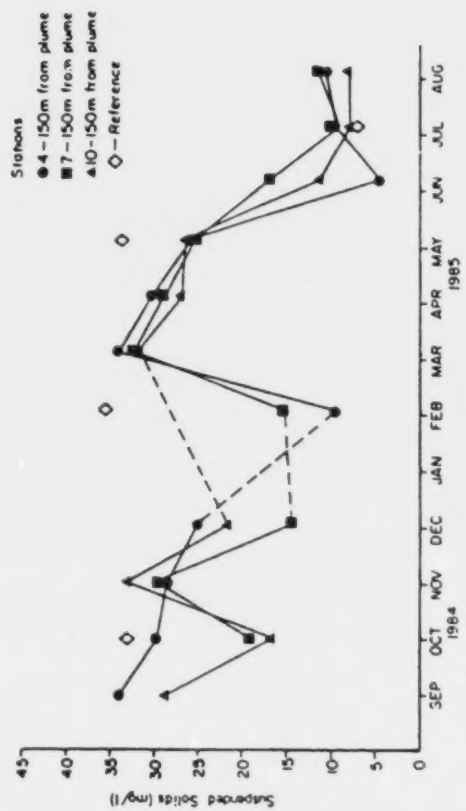


FIGURE: 5.119 MONTHLY AVERAGES OF SUSPENDED SOLIDS FOR THE SURFACE STATIONS, 150 m FROM THE PLUME AT DUFFUS STREET.

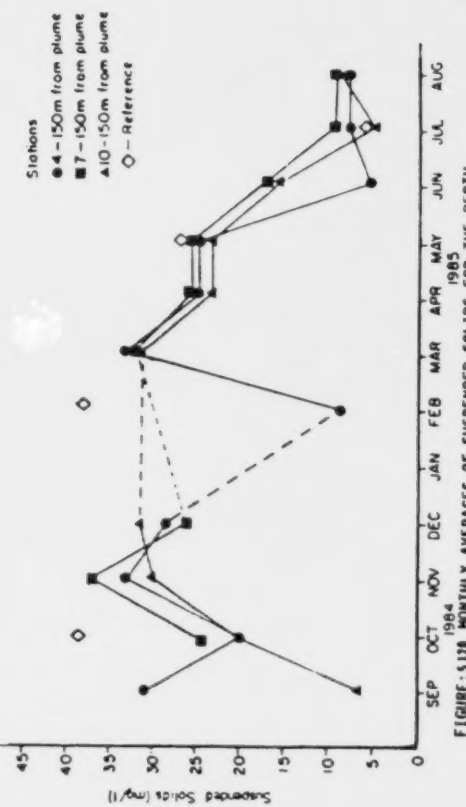


FIGURE: 5.120 MONTHLY AVERAGES OF SUSPENDED SOLIDS FOR THE DEPTH STATIONS, 150 m FROM THE PLUME AT DUFFUS STREET.

Table 5-12 Percent reduction of Suspended Solids in comparison with the discharge point or the manhole at Duffus Street outfall, due to dispersion, assimilation and removal by tides and currents.

Month	Source Strength	% reduction from the source at the 50 meter stations	% reduction between the 50 and the 100 meter stations	% reduction from the source at the 100 meter stations	% reduction between the 100 and 150 meter stations	% reduction from the source at the 150 meter stations
September 1984	28.3*	16.4 S 29.9 B	-13.0 S 21.8 B	3.4 S 51.7 B	-14.4 S -18.8 B	-11.0 S 32.9 B
October	34.2*	38.0 S 51.9 B	18.4 S -4.5 B	56.4 S 47.4 B	-20.1 S -11.4 B	36.3 S 36.0 B
November	32.2*	27.8 S -8.2 B	8.0 S 17.9 B	35.8 S 9.7 B	-30.3 S -13.0 B	5.5 S -3.3 B
December	27.0*	3.7 S 6.8 B	0.0 S 21.0 B	3.7 S 27.8 B	21.0 S -21.7	24.7 S 6.1 B
February 1985	49.0*	56.1 S 68.1 B	7.5 S -25.1 B	63.6 S 43.0 B	11.4 S 39.6 B	75.0 S 81.6 B
March	68.4*	50.3 S 47.9 B	4.1 S 4.9 B	54.4 S 52.8 B	-2.8 S 0.7 B	51.6 S 53.5 B
April	56.9*	52.8 S 38.9 B	-1.9 S 13.8 B	50.9 S 52.7 B	-1.5 S 4.7 B	49.4 S 57.4 B
May	48.4	47.7 S 36.2 B	0.8 S 19.0 B	48.5 S 50.2 B	-1.5 S -0.3 B	47.0 S 49.9 B
June	41.7	74.8 S 76.8 B	-0.7 S -6.9 B	74.1 S 69.9 B	-0.5 S -0.6 B	73.6 S 69.3 B
July	100.8	85.2 S 90.3 B	4.3 S 0.8 B	89.5 S 91.1 B	-5.3 S 1.5 B	84.2 S 92.6 B
August	32.7*	55.4 S 78.3 B	17.8 S 1.0 B	73.2 S 79.3 B	-3.9 S 5.4 B	69.3 S 73.7 B

* Plume
S = Surface
B = Bottom
- = assimilation

The manhole suspended solids ranged from 60.3 to 113.6 mg/L and this was a small range compared to the other two sites. Station 1 outfall values ranged between 18.0 to 76.4 mg/L and 6.3 to 52.5 mg/L for station 4. Hence, there was a medium range of dilution present (48.0 to 71.0%) except for May when an approximate addition of 30.0% was evident at the point of discharge (Table 5-16). The velocity of the Maitland Street pipe (Station 1) and Old Ferry Road sewer pipe (Station 4) was not very high at any time.

Both the minimum and maximum readings (2.0 to 113.3 mg/L) for the stations were present in April indicating seasonal independency. In the late summer and early fall, the suspended solid concentration observed to be greater on the surface than in the bottom waters, while this condition was reversed for late winter and spring. The concentrations of suspended solids in the vicinity of the shipwrecks were fairly similar to the values of station 1 indicating a pooling of the solids by the shipwrecks.

Higher levels of mixing and dilution (80.0 to 90.0%) were observed in the summer months, and fall had the lowest dilution rate (Table 5-13). In a general overview, the percent dilution and removal of suspended solids appeared to be lower than at Duffus Street, however there was an average of 60.0% reduction of the suspended solids present within the waters of Dartmouth Cove. It is important to note that the source strength used for calculation of percent reduction was the sum of the suspended solid values from the two discharge points.

Generally, the winter, spring and summer, suspended solid concentrations were higher in the Cove than in the reference stations. The observed values of suspended solids for Dartmouth Cove were within the recommended values during the fall and spring. N.S.D.O.E. 1976 had reported a range of 7.0 - 211.2 (Mean = 51.2 mg/L) of solids for the manhole which was slightly less than the values reported for this study (Mean = 88.1 mg/L).

Sackville Street

Statistical analysis of the daily data and monthly averages are presented in Table B.3.4 of Appendix B.

Table 5-13 Percent reduction of Suspended Solids in comparison with the discharge point or the manhole at Dartmouth Cove outfall, due to dispersion, assimilation and removal by tides and currents.

Month	Source Strength	% reduction from the source at the 50 meter stations	% reduction between the 50 and the 100 meter stations	% reduction from the source at the 100 meter stations	% reduction between the 100 and 150 meter stations	% reduction from the source at the 150 meter stations
September 1984	56.0*	66.7 S 55.0 S	8.5 S 27.8 S	75.2 S 82.8 S	7.2 S -1.3 S	82.4 S 81.5 S
October	24.3*	21.8 S 35.5 B	40.5 S -2.8 B	62.3 S 32.7 B	-27.3 S -8.3 B	35.0 S 24.4 B
November	36.5*	41.6 S 32.9 B	11.8 S 21.2 B	53.4 S 54.1 B	-13.0 S -24.7 B	40.4 S 29.4 B
December	105.0*	62.5 S 56.5 B	-4.7 S -1.3 B	57.8 S 55.2 B	-5.4 S -0.2 B	52.4 S 55.0 B
February 1985	95.3	70.5 S 71.2 B	0.2 S 1.0 B	70.7 S 72.2 B	-0.8 S -9.8 B	69.9 S 62.4 B
March	77.9	59.5 S 52.8 B	1.7 S 3.4 B	61.2 S 56.2 B	0.5 S 1.8 B	61.7 S 58.0 B
April	113.6	75.0 S 72.8 B	1.6 S -1.3 B	76.6 S 71.5 B	-2.3 S 2.8 B	74.3 S 74.3 B
May	119.9*	68.0 S 66.8 B	6.4 S 2.6 B	74.4 S 69.4 B	0.7 S 2.0 B	75.1 S 71.4 B
June	80.3	86.3 S 89.8 B	-2.3 S -2.5 B	84.0 S 87.3 B	7.7 S -0.9 B	91.7 S 86.4 B
July	84.3	80.9 S 85.6 B	1.7 S -2.8 B	82.6 S 82.8 B	7.9 S 5.2 B	90.5 S 88.0 B
August	105.0	87.1 S 91.5 B	1.5 S -0.5 B	88.6 S 91.0 B	1.0 S -2.1 B	89.6 S 88.9 B

* Plume 1 plus Plume 2

S = Surface

B = Bottom

- = assimilation

Table 5-14 Percent reduction of Suspended Solids in comparison with the discharge point or the manhole at Sackville Street outfall, due to dispersion, assimilation and removal by tides and currents.

Month	Source Strength	% reduction from the source at the 50 meter stations	% reduction between the 50 and the 100 meter stations	% reduction from the source at the 100 meter stations	% reduction between the 100 and 150 meter stations	% reduction from the source at the 150 meter stations
February 1985	101.1	90.0 S 88.8 B	-20.2 S -35.5 B	69.8 S 53.3 B	-5.2 S 22.3 B	64.6 S 75.6 B
March	129.3	75.6 S 75.9 B	-0.6 S 0.2 B	75.0 S 76.1 B	0.3 S -3.9 B	75.3 S 72.2 B
April	60.3	53.9 S 48.9 B	-2.1 S 3.8 B	51.8 S 52.7 B	-4.9 S 4.0 B	46.9 S 56.7 B
May	61.9*	52.0 S 42.3 B	0.5 S 11.3 B	52.5 S 53.6 B	-2.1 S 11.3 B	50.4 S 64.9 B
June	3207.0	99.6 S 99.6 B	0.0 S 0.1 B	99.6 S 99.7 B	0.1 S 0.1 B	99.7 S 99.8 B
July	212.0	95.2 S 97.1 B	1.0 S -0.7 B	96.2 S 96.4 B	-2.0 S 0.0 B	94.2 S 96.4 B
August	217.4	94.4 S 97.3 B	1.9 S -0.3 B	96.3 S 97.0 B	-1.6 S 0.1 B	94.7 S 97.1 B

* Plume
S = Surface
B = Bottom
- = assimilation

Manhole values of suspended solids for this outfall were in the range of 60.3 - 3207.0 mg/L; and the readings of the point of discharge were in the range of 15.0 - 61.9 mg/L. Percent reduction due to dilution was 45.0% during the spring and 96.0% during the summer (Table 5-16), indicating a high velocity at the point of discharge which was not as great as that of Duffus Street.

There were well mixed water columns in the spring, while the surface waters contained more solids in the summer and less in winter. A very small amount of dilution and removal was evident, in the 150 meter surface and bottom stations, with exception of summer. Moreover, the dilution and removal rate for every station was approximately 60.0%, except in the summer (Table 5-14). A predictable pattern of distribution could be established for suspended solid concentrations of this outfall with an exception for June.

The minimum and maximum readings of the daily suspended solid concentrations were 0.7 to 102.7 mg/L, respectively, which was observed in two seasons. A wider range of variation was observed in winter and summer than in the spring.

Values of suspended solids in the Sackville Street plume area were greater than those of the reference stations. These values did not meet the recommended values of 50.0 mg/L for fish and benthic life. Current activity within the area was seasonally regulated, since dilution and removal irrespective of the amount of input varied seasonally.

Pier "A"

Monthly averages and statistical analysis of the daily data are presented in Table B.3.5 of Appendix B.

Manhole samples of Pier "A" had a range of 8.0 to 90.3 mg/L and the point of discharge had a range of 13.0-137.0 mg/L. Reduction due to dilution ranged from 34.0 to 70.0% from the manhole to the outfall (Table 5-16). The overflow pipe suspended solids concentration ranged from 17.6 - 97.5 mg/L and similar to the range of the values of plume 1. A relatively good range of percent reduction due to dilution was present.

There appeared to be less uniformity in the concentration of suspended matters between the surface and bottom waters in the first 400 meters of Pier "A" (Table 5-15A & B). Stations 5 and 6, located outside the confinements of the Pier, showed higher values of suspended solids in the bottom waters in February and March. The summer concentrations of suspended matter were higher in the surface waters, while in the other months there was a mixed behaviour. The irregular concentrations of surface and bottom waters could be attributed to the characteristics of the seawater movement during these periods.

The range that was observed from the daily data (1.2 - 251.3 mg/L) indicated a reasonable level of solid removal at stations 5 and 6. Furthermore, this data showed smaller concentrations of suspended matter during the summer months. This condition prevailed in summer and spring for all the other outfall sites. Hence, there should have been a marked elevation of various activities plus the process of the spring thaw as well as storm runoff present within this tributary area during the spring season.

A comparison between the plume waters of Pier "A" and waters of the adjacent reference sites indicate a larger concentration of suspended solids in the outfall area in every season. This concentration neither returned to the reference values nor to the recommended values. Averages of the suspended solid concentrations for the manhole were higher than the 51.0 - 68.0 mg/L observed by N.S.D.O.E. 1976.

Summary

Variable ranges of initial and secondary dilution were observed in every outfall site during each season. The rate of dilution was a function of the wastewater input, volume of the water in the site, the accessibility of the site to the Harbour water circulations, and presence of spring thaw and storm runoff. In the case of Pier "A" where the City of Halifax deposits its snow, the waters received direct input of suspended matters during the winter months.

The comparative study between the references and the plume waters indicated a close correlation between the concentration of the suspended solids. However the quality of the solids captured on the filter mat was very different. Photoplate 8 is the best indication of this fact.

Table 5-15A Percent reduction of Suspended Solids in comparison with the discharge point or the manhole at Pier "A" outfall, due to dispersion, assimilation and removal by tides and currents (plume 1).

Month	Source Strength	% reduction from the source at the 200 meter stations	% reduction between the 200 and the 400 meter stations	% reduction from the source at the 400 meter stations	% reduction between the 400 and 450 meter stations	Source Strength	% reduction from the source at the 450 meter stations
February 1985	72.9	52.0 S 61.2 B	-12.5 S 8.7 B	64.5 S 52.5 B	13.2 S 1.7 B	63.1 S 71.8 B	51.3 S 50.8 B
March	86.0	61.7 S 58.1 B	3.9 S -3.8 B	57.8 S 61.9 B	-4.3 S 4.9 B	85.8 S 82.3 B	62.1 S 57.0 B
April	57.5	58.1 S 98.3 B	6.6 S 37.3 B	51.5 S 61.0 B	-12.6 S -2.4 B	75.5 S 70.0 B	64.1 S 63.4 B
May	70.7*	62.4 S 62.9 B	3.8 S -6.1 B	58.6 S 68.5 B	-4.1 S -1.7 B	75.9 S 68.9 B	62.7 S 70.2 B
June	90.3	81.7 S 86.5 B	1.7 S 0.3 B	80.0 S 86.2 B	11.4 S 12.0 B	56.4 S 50.8 B	68.6 S 74.2 B
July	137.6*	87.9 S 92.8 B	-3.2 S 8.1 B	91.1 S 84.7 B	3.9 S -10.2 B	109.8 S 118.5 B	87.2 S 94.9 B
August	42.3	79.2 S 84.0 B	1.2 S -4.7 B	78.0 S 88.7 B	5.2 S 12.4 B	26.9 S 22.4 B	72.8 S 76.3 B

* Plume
S = Surface
B = Bottom
- = assimilation

Table 5-15B Percent reduction of Suspended Solids in comparison with the discharge point at Pier "A" outfall, due to dispersion, assimilation and removal by tides and currents (plume 2).

Month	Source Strength	% reduction from the source at the 200 meter stations	% reduction between the 200 and the 400 meter stations	% reduction from the source at the 400 meter stations	% reduction between the 400 and 450 meter stations	Source Strength	% reduction from the source at the 450 meter stations
February 1985	37.2	17.5 S 5.1 B	-5.6 S -11.0 B	23.1 S 16.1 B			
March	49.5	34.3 S 28.5 B	3.6 S -1.8 B	30.7 S 30.3 B			
April	47.6	43.1 S 46.2 B	-3.5 S 3.8 B	46.6 S 42.4 B			
May	46.6	39.3 S 56.0 B	-12.8 S 15.4 B	52.1 S 40.6 B			
June	38.3	53.8 S 65.8 B	-11.5 S 0.5 B	65.3 S 65.3 B			
July	97.5	85.6 S 93.7 B	-3.2 S 1.5 B	88.8 S 92.2 B			
August	17.6	58.5 S 69.9 B	4.5 S 4.0 B	54.0 S 65.9 B			

S = Surface
B = Bottom
- = assimilation

STATIONS	PARAMETERS	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG
TUFTS COVE	C.O.D.			-320%	-80%	-330%	-570%	36%
	B.O.D.	-310%	55%	66%	75%	2%	74%	13%
	S.S.	51%	67%	41%	-40%	-150%	71%	40%
DUFFUS STREET	C.O.D.			-10%	-20%	14%	-60%	58%
	B.O.D.		-1%	21%	70%	83%	30%	53%
	S.S.		-10%	-90%	6%	35%	13%	-20%
DARTMOUTH COVE	C.O.D.			-180%	80%	44%	44%	2%
	B.O.D.	66%	65%	76%	73%	72%	27%	65%
	S.S.	63%	57%	48%	-30%	71%	66%	57%
PIER A	C.O.D.			74%		71%	32%	0%
	B.O.D.	80%	82%	83%		42%	50%	72%
	S.S.	53%	45%	34%		60%	70%	70%
SACKVILLE STREET	C.O.D.			62%		61%	30%	53%
	B.O.D.	88%	92%	80%		82%	74%	91%
	S.S.	40%	56%	30%		99%	91%	93%

Formula: $-(\text{Pollutant strength discharged by the plume/input manhole} \times 100) - 100$

Table 5-16 PERCENTAGE REDUCTION OF POLLUTANTS DUE TO DILUTION
FROM THE MANHOLE TO THE PLUME

Tufts Cove, Pier "A" and Dartmouth Cove receive a large quantity of suspended solids continuously, especially during apparent spills and storm conditions. Occasionally Sackville Street had high suspended solid concentrations. The expected high solid loadings from Duffus Street sewer was not prevalent.

The Harbour waters received and contained more suspended solids than the site outside the Harbour. However the plankton bloom during spring and summer altered this condition. On average the Harbour waters contained more suspended solids than these limits recommended.

5.1.9 Analysis and Discussion of the Monthly Data for pH

The pH is a measure of $[H^+]$, Hydrogen ion, of the water resulted from several chemical equilibria. It also is a measure of the free hydrogen ions that are not involved in a reaction with the carbonates or bases, that in turn demonstrates the acid or alkaline capacity of the solution. The pH of the water columns is controlled by the chemical, biological and microbiological activity present in the environment.

Natural waters have a pH of 4.00 (100 micro g/L $[H^+]$) to 9.00 (0.001 micro g/L $[H^+]$). However, seawater has a pH range of 7.00 (0.01 micro g/L $[H^+]$) to 8.50 (0.003 micro g/L $[H^+]$) which is in the neutral to alkaline range. A pH range of 8.00 (0.01 micro g/L $[H^+]$) to 8.30 (0.005 micro g/L $[H^+]$) has been recommended for seawater by Water Quality Criteria, 1972 and the optimum and maximum standard of pH for swimming and fishing was set as 6.50 - 8.60 (0.32 - 0.003 micro g/L $[H^+]$) and 6.50 - 8.50 (0.32 - 0.003 micro g/L $[H^+]$), respectively.

Tufts Cove

Monthly averages of pH and the respective statistical analysis of the daily data are presented in Table B.4.1 of Appendix B. The graphic representation of the results are illustrated in figures 5.121 to 5.126.

Average pH values at the point of discharge in Tufts Cove ranged from 8.30 to 7.16 (0.005 to 0.07 micro g/L [H+]) in every month. However, this range was not an indication of the discharges for December and February, since during this time the presence of industrial effluent and the lime altered pHs to respective ranges of 6.73 to 10.68 (0.19 to 0.00002 micro g/L [H+]) and 7.51 and 9.03 (0.03 - 0.0009 micro g/L [H+]). The pH of the manhole samples in every case was at least 1 unit less than the pH's at the discharge site, this was an indication of a certain amount of dilution.

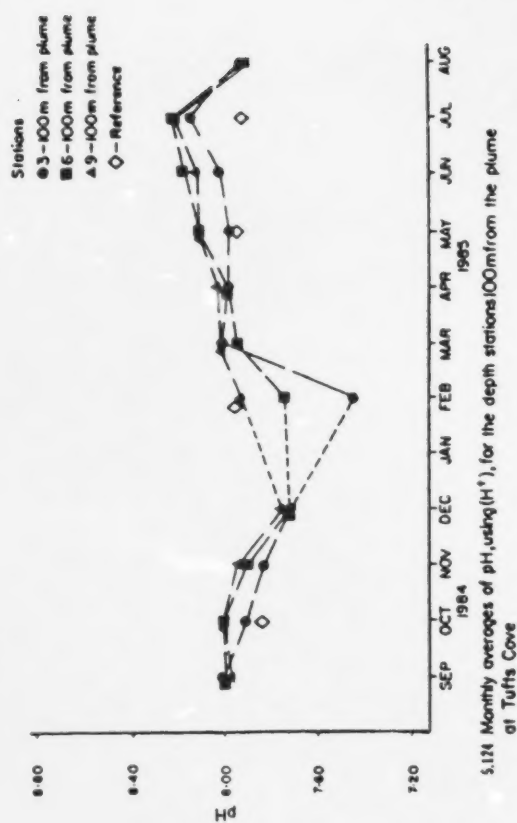
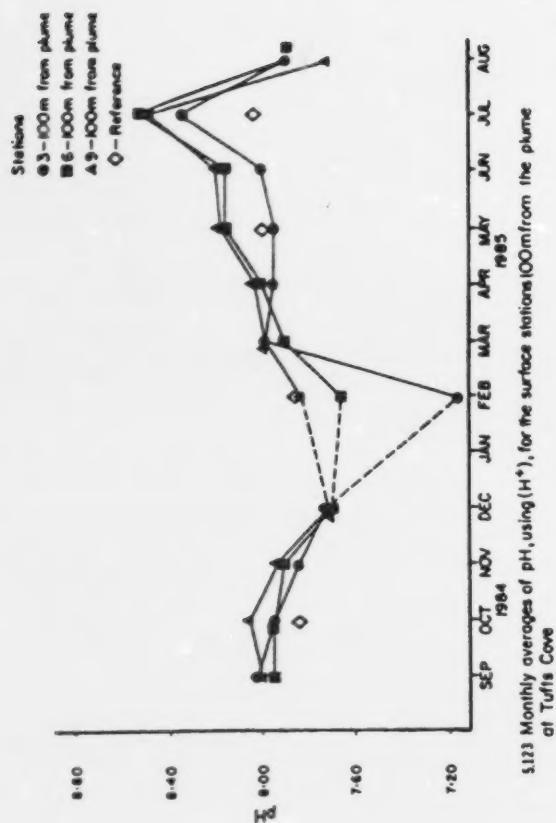
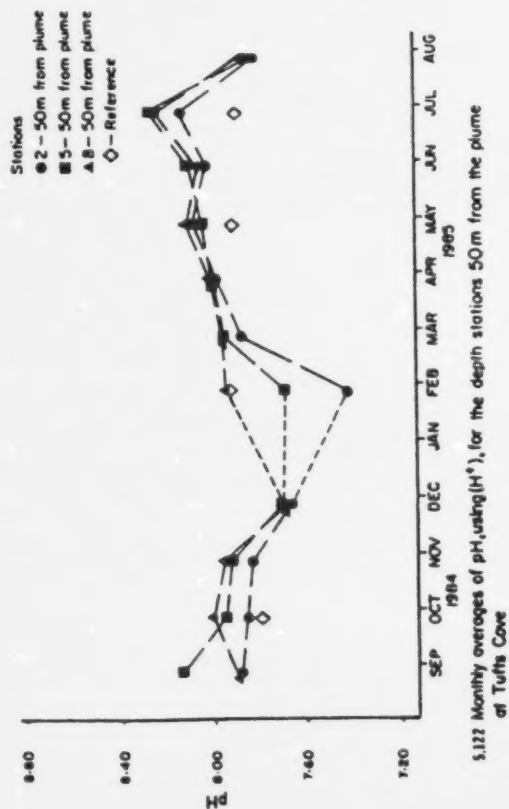
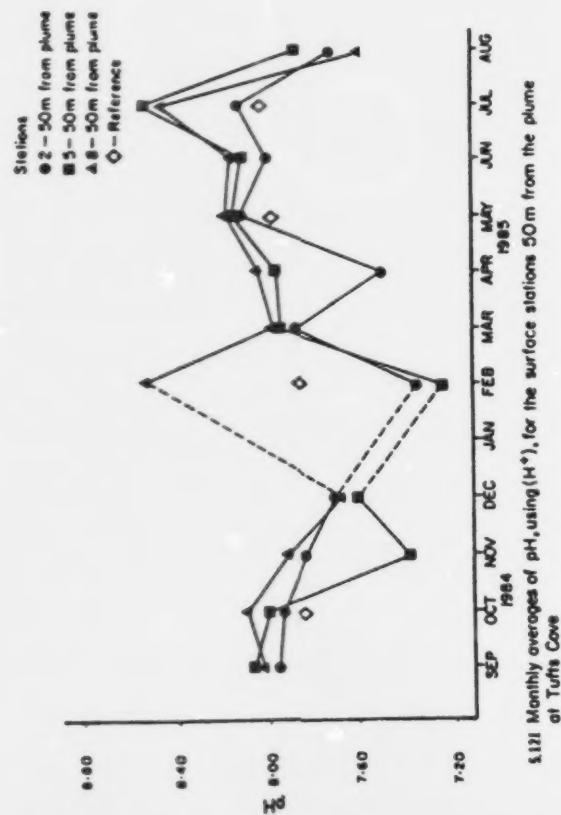
The pH ranges within 150 meters of plume area were observed to be from 8.59 in July to 6.78 in August (0.0026 - 0.166 micro g/L [H+]). Higher pH values were observed for February and July, while the lower values were present in October and February. Hence, the pH changes did not show a significant correlation with the station or month. However, pH averages of the late fall, winter and early spring were predominantly in the range of 7.0, while the other months were in the 8.0 range.

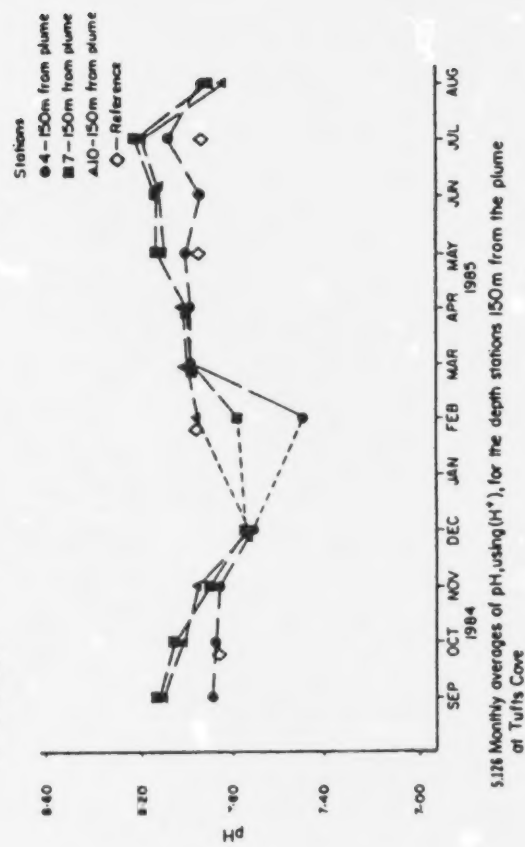
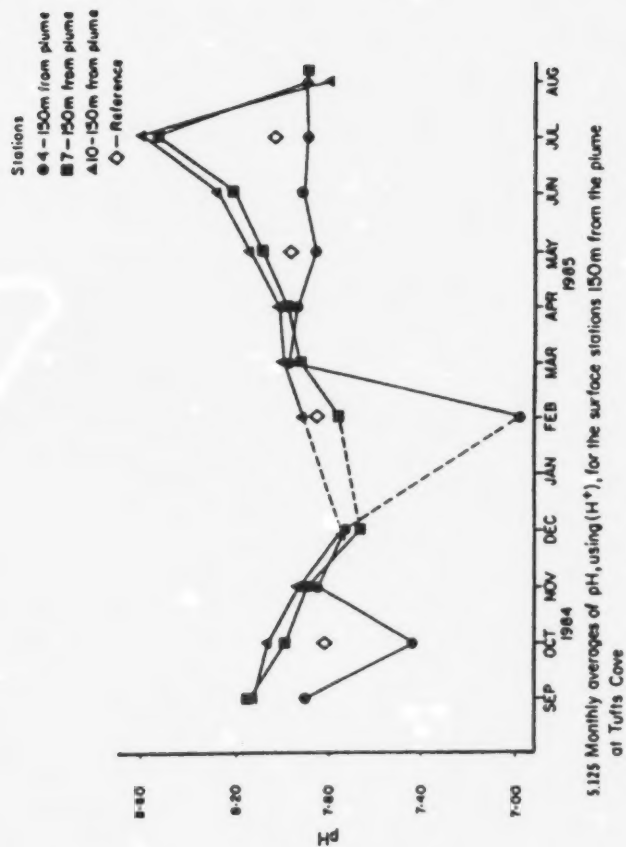
Generally, pH values of Tufts Cove were within one unit of the recommended range for fishing, with exceptions for the apparent "spill" cases. Even though these abnormal discharges occurred on different occasions, the related pH values are not evident in the monthly data due to averaging of the daily values.

The pH variations between the stations of Tufts Cove were erratic; these fluctuations were more evident for the surface than for the bottom. The pH values of the 100 meter stations for surface and bottom correlated, while the 50 and 150 meter stations did not show any indication of this correlation.

Stations 2, 3 and 4 located adjacent to the mudflats in the Cove almost always had lower pH values than the other stations. This condition suggests the containment of the contaminants in this area and possibly the shallowness of this area was a hindrance on the mixing and dispersion function of sewage and seawater.

The reference stations had the same pH ranges as the cove waters. The pH values of the manhole, observed by this study over a year, indicated readings in the same range of 7.17, reported by N.S.D.O.E., 1976.





Duffus Street

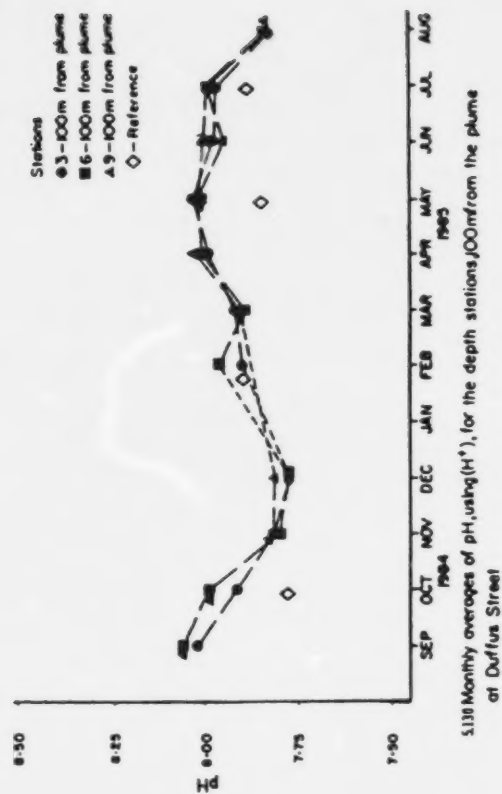
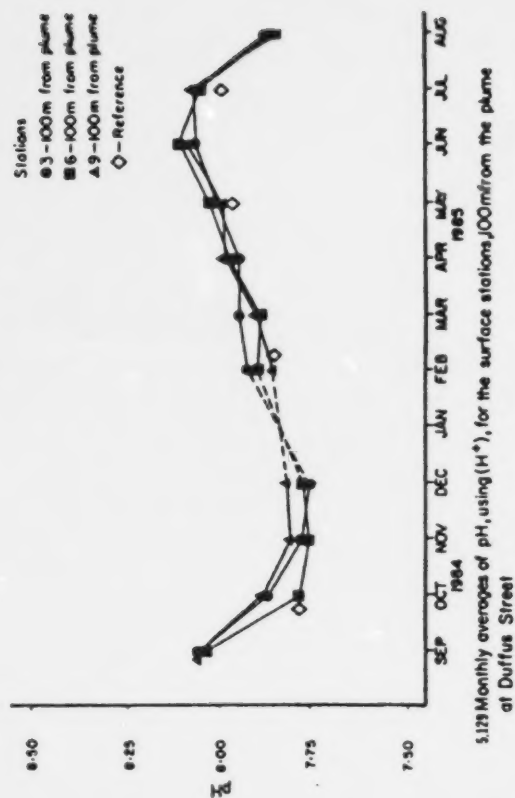
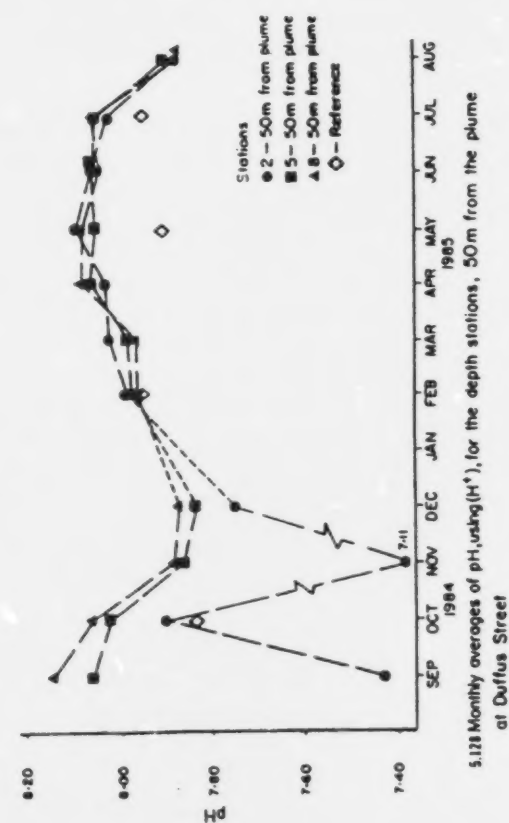
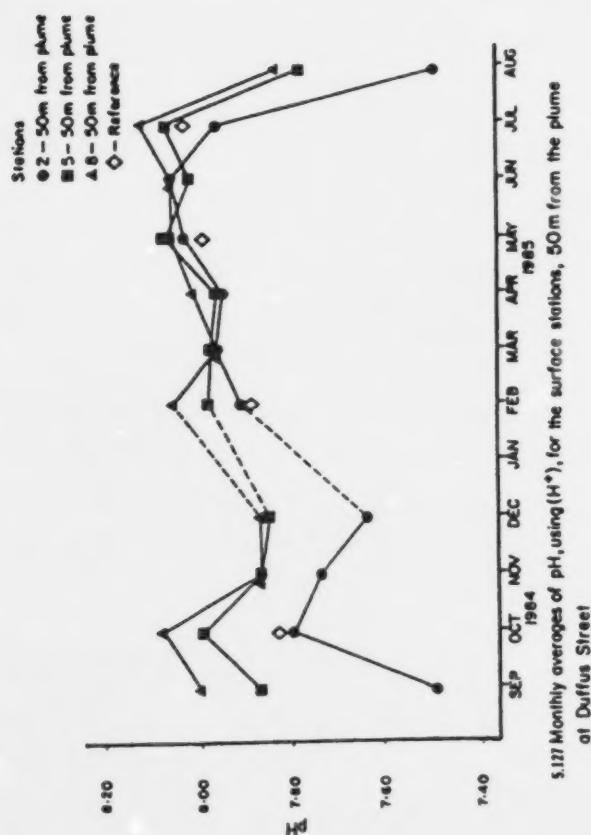
Monthly averages of pH and the statistical analysis of the daily data are illustrated in Table B.4.2 of Appendix B. The corresponding graphs are presented in figures 5.127 to 5.132.

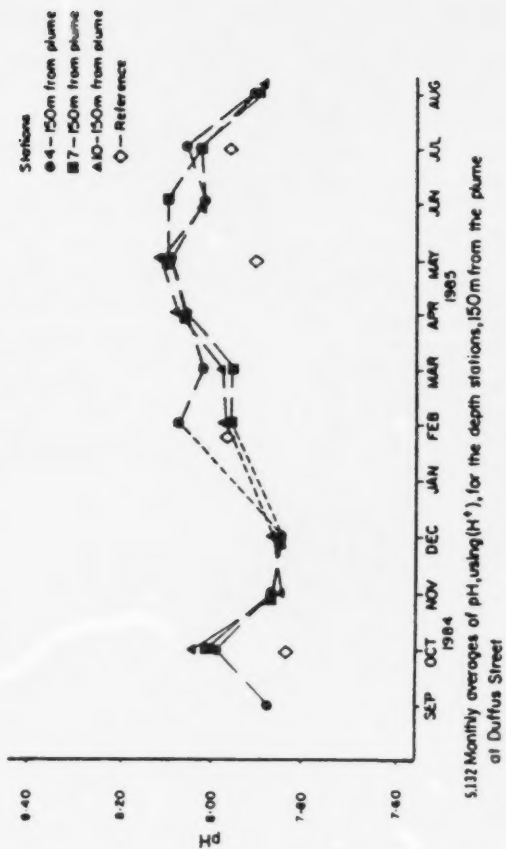
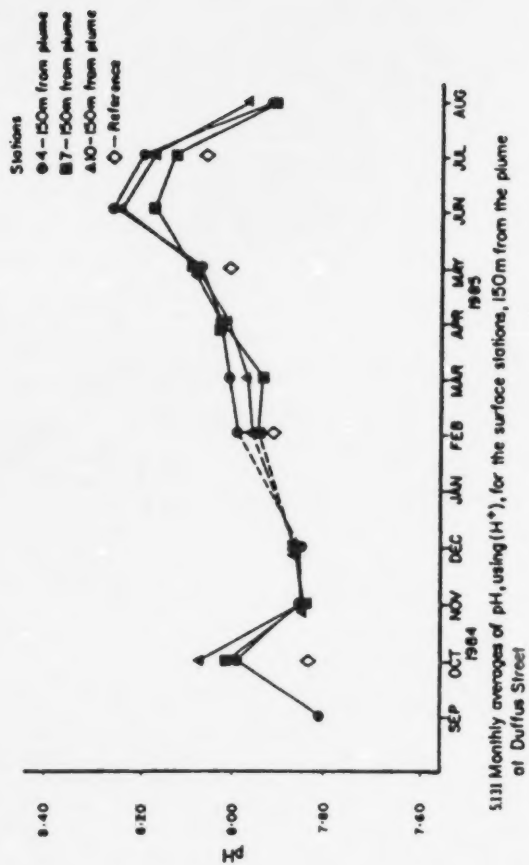
The pH values from the manhole to the point of discharge only varied by 0.09 to 1.07 units. Such a small variation between the two pH's indicated a relatively low level of dilution. The maximums and minimums of the daily data were within the range of 8.0 to 7.0 except for July and August when the minimums were 6.28 and 6.89 (0.525 to 0.128 micro g/L [H+]), respectively. The average pH of the discharge point was always in the neutral range of 7.0 to 7.70 with an exception for September. There were no unusual effluents emanating from the Duffus Street outfall during the study period.

During the fall and winter, the pH of the stations was in the neutral range of 7.0 to 7.70, while in the other months samples of the outfall waters had a pH range of 8.0. Within 150 meters of the monitored area, the higher values of pH were observed in June and July and the lower values occurred in September and November. Therefore, there is a distinct trend of high pH values in the summer months and lower values in the fall months.

The distribution pattern of pH values for the Duffus Street plume waters was very uniform and the pH fluctuations were not distinct beyond the 50 meter stations. The pH readings for station 2, during every month of sampling were lower than the values of the other 50, 100 and 150 meter stations. Hence, emphasizing a containment of the effluents at station 2. This could be an indication of the pooling of sewage against the Volvo wharf by the tidal and current forces. A variation of 0.5 pH units was evident between the surface and bottom waters of all stations, indicating a uniform dispersion of the effluent in the water column. The pH values of the 150 meter stations of 4 and 7 were slightly higher than the 100 meter stations and these values were similar to those for the reference site.

Generally, the pH values of Duffus Street were observed to be within the recommended limits for fishing and swimming waters. The average of the manhole values were within the same range of 7.14 (0.072 micro g/L [H+])





reported by N.S.D.O.E. 1976. Moreover, the reference pH values were lower than those of the Duffus Street plume waters. A comparative view between Tufts Cove and Duffus Street waters indicates that the pattern of distribution and the effect of water movement varied pH values between the two sites. Tufts Cove had a wider range of pH values. There was also a distinct horizontal and vertical dilution and dispersion of sewage in the water column of Duffus Street that was not observed at Tufts Cove. However, in either case variable levels of pooling of the contaminants were present.

Dartmouth Cove

Monthly averages and the statistical analysis of the daily data are illustrated in Table B.4.3 of Appendix B.

The discharge point and manhole pH averages were in the range of 6.86 to 8.00 (0.138 - 0.01 micro g/L[H⁺]) and had a wider range of variation than those of Duffus Street. Daily pH data, indicated a range of 5.00 to 8.26 (10 - 0.0055 micro g/L [H⁺]) and also had a wider range than those observed in the waters of both Tufts Cove and Duffus Street.

During the fall and winter months, the pH values of the 150 meter stations were higher in the bottom than at the surface; this trend was not observed in spring and summer. Higher pH values for the manhole and discharge points were observed in September and June, while the lower pH values were present in November and December.

Generally, the pH values of the Cove show greater variation than those observed for other outfall sites. There was an increase in pH readings for the reference stations in the vicinity of the cove during every season except for fall. The reported N.S.D.O.E. 1976 manhole pH range of 7.07 (0.09 micro g/L [H⁺]) was slightly lower than the Maitland Street average of this study (7.2).

Sackville Street

Monthly averages and the statistical analysis of the daily data are presented in Table B.4.4 of Appendix B.

The pH range of the manhole samples was 7.63 to 8.65 (0.023 - 0.002 g/L [H+]). The pH values indicated a low reduction due to dilution from the manhole to the discharge point. The pH values of the plume waters were observed to be generally higher than all the other outfall sites

The pH of the surface and bottom waters for all stations appeared to be uniform in the winter months while there was a slight variation in these values in the summer months. This condition could have been due to a higher amount of discharge or lower dilution of the plume waters. During the summer months the pH values of the Sackville Street outfall were observed to be higher than those present in the reference stations.

Generally, the waters of this site were very uniform and more closely related to the seawater pH. Very small fluctuations were observed between the pH values of the winter, spring and summer months. The water column of this site showed a marked vertical mixing.

Pier "A"

The monthly averages and statistical analysis of the daily data are presented in Table B.4.5 of Appendix B.

The outfall at Pier "A" had a pH range of 7.08 to 7.51 (0.083 - 0.03 micro g/L [H+]) at station 1, while pH values of station 4 were 7.57 to 8.08 (0.027 - 0.008 micro g/L [H+]), these values were much closer to the range of seawater. However, there was a small indication of a pH change due to dilution at either point of discharge. The average pH values of the Pier "A" discharge were similar to Duffus Street, lower than Sackville Street, but higher than the other outfall sites.

The pH values of the bottom stations were higher in the winter and spring months, while during the summer months higher values were present on the surface of the plume waters. The values of pH in the Pier stations were always lower than the reference sites.

Generally, the pH of the Pier "A" waters appeared to be more acidic than the Harbour waters. Fluctuations of the pH values within the water column

varied slightly for every season. Comparative station values indicated a low level of dilution at the point of discharge. The average pH values at the Pier "A" manhole were slightly greater than 7.00 (0.1 micro g/L [H+]) reported by N.S.D.O.E. 1976.

Summary

The pH analysis of the plume waters did not indicate the same sensitivity as it would if the wastewater was being discharged to a fresh water body. Ionic concentrations of seawater apparently had an effect on the pH of the sewage, since on occasions the low pH's of the effluents were reverted to the neutral to alkaline level. However, this condition prevailed in deeper water bodies, with more dilution capacity, while Tufts Cove and Dartmouth Cove showed the hindrance of shallowness and their inaccessibility.

In every case the pH of the outfall areas returned to the 7.0 - 8.5 range. However, the reference sites indicated variable pH readings both in comparison with the reference station outside the Harbour and the plume area of the outfall sites. This variability could have been derived from the level of physical movement of water from the chemical, biological and microbiological activities of the organisms and the contaminants.

The pH of Halifax Harbour away from the outfall sites, were approximately +1 unit from the "normal seawater" standard set by the Water Quality Criteria, 1972, and the observed values of the reference site outside the Harbour. For fishing and recreational use of Harbour waters, which has an optimum range of 6.8 to 7.2 (0.158 - 0.063 micro g/L [H+]), within the 150 meters of plume waters pH's were more in the critical range of 6.5 to 8.5 (0.316 - 0.003 micro g/L [H+]). The pH of the reference sites were in the range of 7.52 to 8.34 (0.03 - 0.005 micro g/L [H+]), hence, the waters in the middle of the Harbour are within the optimum range for fishing and bathing.

5.1.10 Analysis and Discussion of the Bacteriological Results

Disposal of untreated sewage into the seawater by the seashore outfalls has a public health impact by elevating the risk of the outbreak of infectious

diseases, as it is the case for Halifax and Dartmouth. Coastal communities such as Halifax and Dartmouth are at a risk of the introduction of epidemics by incoming ships, commodities and people.

The Thalassogenic (Greek=sea source) infections resulting from the practice of raw sewage disposal have been documented from 1896. Primary mechanisms by which these infections spread: (a) ingestion of water by voluntary immersion (swimming), (b) ingestion of water by involuntary immersion (accidental), (c) digestion of contaminated fish and shellfish, and (d) sea spray where the outfalls are in the vicinity of inhabited areas.

Domestic sewage contains a large number of disease-causing viruses, bacteria and parasites. Some of these microorganisms are already present and ubiquitous to the marine environment, some others can continue to survive in saline water. The entriobacteria have less chance of survival in cold, saline water. Psychrophilic (Bacteria surviving in temperatures of 4-10°C), some mesophilic (20-40°C) and the spore forming as well as the natural flora of the marine sediments and water environment could survive.

Microbiological contamination of sanitary sewage has been classified by Public Health Engineers into two groups of indicative bacteria, Total and Faecal Coliforms. In either of the two groups there are heterotrophic and autotrophic bacteria present, which are the natural flora and fauna of humans, animals, soil, mineral sources, plants, decaying plants and water. Important organisms of these two groups are described to give a quantitative value to the bacteria that has been monitored and others that are of significance.

Total Coliform: These organisms originate from soil, sediment, plant and animals as well as humans. Various strains of *Escherichia*, *Klebsiella*, *Aerobacter*, *Entrobacters* and *Citrobacters* are present in this group of organisms. All the aerobic and facultative anaerobic, gram negative, non-spore forming, rod-shaped bacilli which ferment lactose and produce gas within 48 hours at 35°C are known as "coliforms". This group of bacteria differs significantly in their biochemical and serological characteristics and in their sources and habitats. *Escherichia coli* is an inhabitant of the intestine of humans and animals, while *Aerobacter* are found on vegetations and in small numbers in human faeces. Therefore, all the waters and soils that

have received pollution in the past contain variable amounts of coliforms. The ratio of "Intermediate Aerogenes Cloacae" (IAC) to E. coli at any time indicates the relative time and nature of pollution discharges.

Faecal Coliforms: These group of microorganisms are strictly originated from the faeces of human and warm blooded animals. These microorganisms are different from Total Coliforms, since they are lactose-fermenting, gas-forming bacteria. The presence of faecal coliforms indicates a recent faecal contamination; Escherichia coli is the predominant strain in this group of bacteria.

Escherichia coli is a normal flora of the intestine of humans and animals and survives for more than 24 hours in seawater (Livingstone, 1978). E. coli is present in concentrations of 10^8 /gm of human faeces. This bacteria is known to survive on very small amounts of nutrients, so their presence in beaches close to an outfall, in the sediments of the 10 km radius of the outfall site or disposal sites of sludge and septic content are understandable. Although, heavy metal content of sewage, sludge or seawater is toxic to most organisms, E. coli is known to resist and survive 10^{-6} mg of metal ions in an organically rich environment (Jones and Cabot, 1974).

Total and Faecal Coliform sampling and analysis for the outfall sites were compiled during the spring and summer of 1985. Because of the limited number of samples and stations monitored the following results can indicate limited bacterial quality of the Harbour waters.

Total and Faecal Coliforms at the points of discharge from all the outfall sites were greater than 3000 during every sampling month. During June Total Coliform count was TNTC at Pier "A" and 54 at Tufts Cove. Faecal Coliform of 54 at Tufts Cove and 20 at Pier "A" during the same month were the exceptions. The low Coliform count at Tufts Cove sewer pipe indicated a bacterial kill by chemicals since observation 100 meters away from the discharge point indicated higher counts. Sackville Street and Pier "A" outfall pipes had discharged effluents with greater than 3000 of bacterial density, with an exception of June when readings were TNTC (Tables 5-17 to 5-22).

For the stations 100 and 150 meters away from the discharge point at Duffus Street, Total Coliform was observed to be in the range of greater than 3000, except for two months when these counts dropped to 100. Generally, Duffus Street had comparable bacterial density on the surface and the bottom of the water column. Faecal Coliform count indicated a sewage override at this site.

Tufts Cove had an unusually low Coliform count with irregular patterns of distribution in the 100 and 150 meter stations. Since there was no specific pattern to the density of microorganisms on the surface versus the bottom of these water columns an unusual chemical condition should have prevailed in this water column. The bacterial density of the 50, 100 and 150 meter stations was suppressed during April due to the cold environment of the Cove which had also induced a bacterial kill.

Dartmouth Cove had a Total Coliform count in the range of greater than 3000 to 70 per 100 ml with a distinct elevated bacterial density on the surface of the water column indicating an override. This phenomenon could also be due to the level of precipitation of the bacteria to the sediment.

The plume area of Sackville Street outfall had a similar Coliform distribution pattern as Duffus Street with exception for station ten (150 meters away) which had a larger bacterial density compared to station eight (100 meters away). The bacterial reduction was evident in the plume area of this site. Pier "A" had greater density of Faecal and Total Coliforms nearly 600 meters away from the tunnel sewer outfall at station 1 and 100 meters from the pipe outfall, station 4; this was an indication of a large Coliform input and slow removal rate, as well as very slow seawater replacement. The sewage override was also evident especially for Faecal Coliform counts.

In comparison to the reference site, from every outfall site, there was a net transportation of Total and Faecal Coliform to the middle of the Harbour. However, it is important to note that the width of the Harbour close to Sackville Street and Dartmouth Cove was approximately 2.4 km, hence the reference sites were located further from the outfalls than those by Duffus Street and Tufts Cove.

Total Plate Count: procedures of this test provides a measure of the density of aerobic and facultative anaerobic heterotrophic bacteria of the waste water. Since each strain of bacteria requires specific growth media and optimum temperature, the Total Plate Count test only supports the growth and measures the density of certain strains of bacteria present in the effluent. Hence, this empirical variability count is estimating a lower density of bacteria than the actual measure of the bacterial density in the sample.

A measure of TNTC of bacteria emanated from Duffus Street, Tufts Cove, Dartmouth Cove, Sackville Street and Pier "A" outfalls during spring and summer of 1985. This condition was very unusual, considering that Total Plate Count should be comparable to Total and Faecal Coliform values. By an increase in the frequency of sampling, pooling the results and plotting the values, a clear interpretation could be provided (Tables 5-17 to 5-22).

The Total Plate Count was substantially higher in the surface waters of the plume areas at every outfall site. In these cases the hydrodynamic movement of sewage on seawater appeared to be the primary mechanism of dispersal. On one occasion, during April, the Total Plate Count was TNTC throughout the plume area of Duffus Street that also coincided with high Total Coliform and Faecal Coliform counts. Tufts Cove plume area also had a TNT count of bacteria during June, that coincided with elevated Staphylococci and Pseudomonas counts showing the disposal of septic tank content into the sewer. Elevated levels TNTC of Total Plate Count was encountered in August within Dartmouth Cove waters, that coincided with high Total, Faecal and Staphylococci count (TNTC); considering there was no known septic tank slurry disposal present within the area this condition was unusual. Sackville Street plume waters had high Total Plate Count, but this elevated level does not correspond with an increase in the density of other bacterial strains. There was more bacterial removal and elimination in summer. The Total Plate Count for the waters of Pier "A" was very high (TNTC). Elevated Total Plate count, in this case, was closely related to high Total, Faecal Coliform and Staphylococci count, and had no correlation with Pseudomonas density. Generally, there was no indication of bacterial removal or elimination from Pier "A".

There was clear evidence of bacterial spills from all the outfall sites. Also, there is a need for a more comprehensive assessment of the bacterial transport into the middle of the Harbour.

Even though Total Plate count is a gross count of bacterial density, in each location the ratio of other bacteria and Total Plate count signifies the quality of sewage discharged. Except in the case of Pier "A", other sites had an indication of low bacterial removal or elimination by various mechanisms, Pier "A" showed no indication of bacterial kill or even dilution. The presence of septic tank slurry in some outfall sites was supported by the measurement of this parameter.

Staphylococci are a series of gram-positive cocci that are irregularly arranged in a cluster. These facultative anaerobes are the principal cause of supportive infections, which may vary from simple infection to food poisoning and life-threatening abscesses in various internal organs. Staphylococci are a normal flora of skin, 30 to 50% of people carry this organism in the mucoid tissues of the ear, nose and throat. S. aureus can be isolated from human intestine, dogs, cats and pigeons. This strain of bacteria is the most predominant one in the effluent from hospitals since an average of 50 to 75% of the personnel and patients are carriers. Some strains of this group of bacteria need a rich medium and temperature of 25-40° for their survival, and can only tolerate 10 ppt salt content. However, majority of the bacteria are resistant to low temperatures, high salinity, elevated heavy metal ions and can survive low dissolved organics. Staphylococci and Pseudomonas are amongst the more persistent pathogens of sanitary sewage. Due to their availability and high survival rate in poor conditions, their presence in the vicinity of recreational and fishing areas are of great concern.

Staphylococci emanating from the sewer pipes at Duffus Street, Tufts Cove, Sackville Street and Pier "A" was TNTC. Total and Faecal Coliform density of every site was almost always lower than the Staphylococci count; this condition prevailed as far as the 100 and 150 meter stations. The presence of Staphylococci in such elevated levels in every site was an indication of high input to removal ratio of sanitary sewage. A high density of this strain of bacteria had been encountered down stream from the treatment plants in a

freshwater environment and within a 20 km radius of sludge disposal sites in the marine environment. In all the studies that reported this condition, a discrepancy between the density of Coliforms and Staphylococci bacteria had been re-emphasized considering both are of human origin (Tables 5-17 to 5-22).

Therefore, the pattern of Staphylococci distribution, for each site, had been a function of the prevailing circumstances in the area. In the vicinity of Duffus Street outfall the bacterial density reached the lowest count at the bottom of station 10 which was 150 meters away. The Staphylococci, Total Plate Count and Pseudomonas count of Tufts Cove plume were indicative of the disposal of septic tank contents in June. During other sampling months no regular pattern of bacterial removal was observed in Tufts Cove waters.

In June, Dartmouth Cove Staphylococci count was 1000 bacteria/100 ml which was comparatively low. Even though there was no documented evidence of septic tank waste disposal within this tributary area, a high bacterial density (TNTC) during summer was unusual.

In the Sackville Street and Pier "A" plume areas the Staphylococci count was observed to be TNTC. There was better indication of bacterial removal from Sackville Street plume waters than there was from Pier "A". The containment of wastewater within the Pier was the apparent reason. Bacterial density in Pier "A" waters dropped below TNTC within 600 meters of the plume area except in April. The presence of hospitals and several hospital-related institutions such as the Tupper building and Pathology laboratories were the primary sources of large Staphylococci output through this sewer trunk.

Staphylococci density in the middle of the Harbour indicates transport of this bacteria from the outfall areas. The larger densities of bacteria, (700-TNTC), were observed in the vicinity of Duffus Street and Tufts Cove.

Pseudomonas is a non-spore forming, flagellated, aerobic bacteria that is a normal flora of soil, freshwater, plants, vegetables and marine water. This microorganism is of interest since it resists household and other common disinfectants. The infections caused by this group are known as "hospital diseases". They are important when considering the Pier "A" water quality since this outfall receives a great amount of effluent from three hospitals and two hospital-related institutions.

This strain of bacteria is a member of floc-forming microorganisms. Their presence in significant levels in the study area could be an indication of either septic tank content or wastewater treatment plant sludge disposal. Its presence in the bottom of the plume waters might indicate decomposition of organics.

Results of the assays showed that the amount of *Pseudomonas* in every site ranged from 0 to TNTC. Such a wide range of bacterial density was basically due to the fact that *Pseudomonas* was ubiquitous to most environments and they appeared to be resistant to cold seawater. Bacterial density at the point of discharge in Duffus Street and Tufts Cove was zero except for May, June and August when the readings were TNTC. Dartmouth Cove had zero *Pseudomonas* count for May, July and August; and TNTC reading for June. In the case of Sackville Street and Pier "A" the TNT Count readings were observed in July and April. Station 4 of Pier "A" continuously had an unusually low *Pseudomonas* counts (Tables 5-17 to 5-22).

It was observed that *Pseudomonas* existed in elevated levels in chlorinated effluents of treatment plants and pooling of the effluents appeared to reduce the bacterial count (Jacques, Whitford and Associates 1984). However, this study indicated a very wide range of readings at the point of discharge. These organisms might have been discharged irregularly or killed by some mechanism before reaching the plume waters. It is important to note that zero *Pseudomonas* count in the sanitary sewage is highly unusual. To qualify the results obtained by this study a more comprehensive monitoring of the outfall area is needed.

At the 100 and 150 meter stations of Duffus Street the surface waters contained more *Pseudomonas* than Tufts Cove. Tufts Cove had TNT count of bacteria in June, while 0 to 10 bacteria for the other months. Dartmouth Cove stations continued to have high bacterial counts within 150 meters of the plume area, and had TNT count in June. The initial *Pseudomonas* count was lower than TNTC for the 150 meter stations in July. An unusually low count of 0-470 of *Pseudomonas* was observed at Pier "A".

Tufts Cove had *Pseudomonas* and *Staphylococci* densities of TNTC which clearly indicated disposal of septic tank content. The reasons for the TNTC

readings throughout Dartmouth Cove and zero *Pseudomonas* reading at station 1 of the other stations were not known and further tests are needed to qualify any hypothesis.

The *Pseudomonas* count almost always increased from the outfall point to the middle of the Harbour with the exception of the times that bacterial density was TNTC.

Faecal Streptococci is a potential pathogen contributed by the upper respiratory and intestinal tracts of warm blooded animals and humans. In the colder environments, as much as 60% of the people carry these organisms in their upper respiratory tracts. Urogenitals' normal and mucoid epidermis contain an average of $10/\text{dm}^2$ of these organisms. The faeces of 25% of normal individuals contain $10^8/\text{gm}$ of these capsule forming, non-sporing cocci. These bacteria, which are in pairs or chains of cocci, need to live in a very organically rich and warm environment; but some strains are capable of forming capsules that assist their survival. The presence of Faecal Streptococci is also a sign of recent faecal pollution. However, presence of a large population of microorganisms at the entrance to the Harbour or the estuaries is an indication of current or tidal "damming effects", (Wilson, Miles, 1964), that pools the bacteria within these waters.

Cabelli (1980) has shown that Faecal Streptococci is the best pollutant indicator when the effluents are being discharged close to the bottom, on the sediment level. Hence, EPA recommends no recreational use or fishing within 8 km from sewer outfalls or the site of sludge deposition, especially fishing for bottom-dwellers. The monitoring of this parameter in Halifax Harbour could be useful since all the sewer outfalls are emanating at the sediment level.

Clostridium perfringens is a non-endospore forming anerobe which is motile and forms a capsule. Their principle habitats are soil and sediment. A bacterial count of 100 to 50,000/gm of soil is normal. Cl. perfringens persist for several years and they are also present in human and animal oral cavities and intestinal tracts.

In the absence of E. coli and Faecal Streptococci, Cl. perfringens is an indicator of remote faecal pollution. Since the spore of the bacteria is capable of resisting toxic effluents, they are good indicators of sanitary sewage contamination associated with chemical-pollutants.

Entericviruses are present in large quantities in the faeces of healthy adults. Nearly 70 new strains of viruses have recently been added to the entericviruses already known. These microorganisms are far more resistant to harsh conditions of seawater and potentially more pathogenic than entericbacteria. Research by Kelly and Sanderson as well as Clark and Kebrer indicates poliovirus and coxsackievirus have a high level of resistance to temperature, salinity and wastewater treatment.

Salmonella and Shigella groups of microorganisms are amongst highly pathogenic bacteria, which are associated with the disposal of raw domestic sewage from institutions. Their presence around the fish and shellfish harvesting grounds is of significant importance, hence an estimate of these microorganisms in the Eastern Passage area should be conducted.

Salmonella provides a speedy measure for evaluating the level of pathogenic contamination (Livingstone, 1964). The presence of Shigella is an indication of recent sewage disposal, while salmonella indicates a more remote source of contamination.

Parasite units the measure of Ova of Taeniai and Ascaris species have proven valuable in "plume tracking" procedures. Their presence provides a gross quantitative measure of sewage pollution, since they only remain in the seawater up to 30 hours before becoming unrecognizable (Livingstone 1980).

In accordance to recommendations of the Department of Inland Waters, the plume of the outfall areas are designated as a "limited use zone" (LUZ). The Fisheries Act prohibits discharge of any polluted or deleterious substances to the estuaries. EPS recommends treatment of sewage and chlorination of the effluent. The effluent of treatment units should not contain more than 400/100 ml of Faecal Coliform. Halifax Harbour contains in excess of 400/100 ml of bacteria.

An estimate of per capita deposition of the indicator microorganism will present a more comprehensive measure of the total bacterial loading.

Avg wet weight of faeces/24 hours/capita	150 g
Faecal coliform	13×10^6 /gm of faeces
Faecal streptococci	3.0×10^6 /gm of faeces
Avg faecal coliform/24 hours	2.0×10^9
Avg faecal streptococci/24 hours	4.50×10^8
Ratio FC/FS	4.4

Survival rate of the microorganisms is significant for the purpose of this study on two distinct levels. First, bacterial kill by any mechanism reduces the possibility of organics being decomposed. Second, survival of sewage-origin bacteria and viruses increases the chance of contamination of waters used for recreation and fishing activities. There are indications that some strains of Total and Faecal Coliform survive an estimated maximum of 200 days in seawater; but the non-spore forming strains of enteric bacteria, except those microorganisms ubiquitous to the marine waters, do not survive the cold seawater more than several hours (Greenberg, 1956 Garbow, 1970). Carpenter, Salter and Weinburger documented removal of 80% of the bacterial content of sewage within the first 30 minutes of exposure to cold and saline waters. Therefore, the rate of bacterial survival as well as the ratio of input to removal of the outfall area was very high in Halifax Harbour. This fact is quantified by analysis of the reference samples which indicate elevated levels of Coliforms, Staphylococci and Pseudomonas within and towards the entrance to the Harbour and the Basin.

Disappearance of viable non-marine bacteria in seawater is a complex phenomenon. Enteric bacteria originate from a warm, nutrient rich and high-energy environment of the intestinal tract. Mechanisms that result in bacterial elimination are: temperature, salinity, dissolved organic carbon, trace metals, diatom and plankton metabolites. Initial reason for bacterial kill has been attributed to the great temperature shock at the point of discharge, because sanitary sewage has an average temperature of 12-18°C and seawater temperatures range from 0 to 14°C. Osmotic imbalance resulting from high salinity and Sodium Chloride related toxicity, are the secondary mechanisms of bacterial pulverization. Consumption of bacteria by other

organisms and the presence of bacteriophages are other mechanisms of bacterial elimination. Bactericidal effects of sunlight, man made chemical contaminants and by-products of pathogenic and non-pathogenic microorganisms are also significant in bacterial kill.

Organics and microorganisms of sewage undergo a "clumping" process once introduced to seawater (Humphrey et al, 1983). Significance of this "clumping action" is based on the availability of organic matters for decomposition, and period and rate of bacterial survival. In this section the latter aspect will be discussed. The bacterial activities take place predominantly on the solid-water interface; as a result a slow detachment of small, decomposed organic particles and bacteria occurs. Precipitation of organics and microorganisms to the level of sediment is the primary mechanism of viral and bacterial survival (Gerber and MacLeod 1976). Furthermore, submerged sewer pipes that discharge effluents to the sediment, as in the case of Halifax Harbour outfalls, provide a medium for deposition of microorganisms (Cabelli, 1980, Izzo, 1984). Sediment supports the bacterial life, and because of its stationary nature, the sludge character is significant in estimation of long term sewage impact. The nature of the sediment (clay versus silt) is important in retaining and removing the bacteria and organics. The deciding factor in the period of settlement and retention is the size of the bacteria associated organic matter. Survival rate of bacteria in the sediment increases since nutrients and organic carbonaceous substances are present plus there is a lack of sunrays (Fujioka et al, 1981). Sludge removal is a function of the hydrodynamic mechanism of plumes, tides and currents, openness of outfall areas to water movements, depth and pipe size and movement of sediments (DeRose et al, 1981). The outfall areas in the Harbour are generally located in shallow areas (0.6 to 10 meters), close to the shore (0.50 to 3 meters), areas surrounded by wharves or coves and contains submerged sewer pipes of variable sizes.

High bacterial density in the summer of 1985 has to be a result of a large input to removal ratio. Furthermore, a brief sediment survey around the outfall indicated that the sludge banks support a low level of aerobic and high level of anerobic bacterial activities; except where large amounts of industrial effluents were present. The magnitude of bacterial contamination is higher than projected by this study. The mechanisms and rates of dispersion and removal are very complex and in need of attention.

TABLE 5-17 RESULTS OF BACTERIOLOGICAL ANALYSIS
FOR TUFTS COVE OUTFALL, 1985

- 222 -

M O N T H	STATION	TOTAL	FECAL	TOTAL	STAPHYLOCOCCUS	PSEUDOMONAS
		COLIFORMS (per 100 ml)	COLIFORMS (per 100 ml)	PLATE COUNT (per ml)	(per 100 ml)	(per 100 ml)
A P R I L	1	> 3000	> 3000	TNTC		
	9	136	32	460		
	9A	228	62	380		
	10	740	42	450		
	10A	162	20	380		
M A Y	1	54	54	TNTC	TNTC	TNTC
	9	> 3000	> 3000	900	TNTC	TNTC
	9A	660	540	TNTC	TNTC	TNTC
	10	120	120	TNTC	TNTC	TNTC
	10A	3000	3000	120	TNTC	TNTC
J U N E	1	> 3000	> 3000	TNTC	TNTC	0
	9	7000	3000	TNTC	TNTC	2
	9A	310	56	46	120	0
	10	500	160	580	200	0
	10A	1000	120	840	TNTC	10
A U G U S T	1	> 3000	> 3000	TNTC	TNTC	TNTC
	9	> 3000	> 3000	280	1100	0
	9A	800	800	170	480	2
	10	1000	420	58	520	0
	10A	1000	920	65	420	2

TABLE 5-18 RESULTS OF BACTERIOLOGICAL ANALYSIS
FOR DUFFUS STREET OUTFALL, 1985

M O N T H	STATION	TOTAL COLIFORMS (per 100 ml)	FECAL COLIFORMS (per 100 ml)	TOTAL PLATE COUNT (per ml)	STAPHYLOCOCCUS (per 100 ml)	PSEUDOMONAS (per 100 ml)
A P R I L	1	> 3000	> 3000	TNTC	TNTC	0
	8	> 3000	> 3000	TNTC	TNTC	0
	10	> 3000	> 3000	TNTC	TNTC	100
	10A	110	32	TNTC	30	0
M A Y	1	> 3000	> 3000	TNTC	TNTC	TNTC
	9	> 3000	> 3000	TNTC	TNTC	50
	9A	1120	46	510	840	0
	10	800	84	470	680	260
	10A	840	8	450	1140	114
J U N E	1	> 3000	> 3000	TNTC	TNTC	0
	9	520	500	840	TNTC	0
	9A	300	70	10	152	28
	10	3400				
	10A	310	80	8	134	14
J U L Y	9	> 3000	> 3000	TNTC	TNTC	0
	9A	> 3000	> 3000	TNTC	TNTC	50
	10	> 3000	> 3000	350	TNTC	0
	10A	> 3000	> 3000	660	TNTC	TNTC
A U G U S T	1	> 3000	> 3000	TNTC	TNTC	TNTC
	9	> 3000	> 3000	250	TNTC	0
	9A	700	660	40	300	0
	10	> 3000	> 3000	250	600	0
	10A	46	0	62	240	0

TABLE 5-19 RESULTS OF BACTERIOLOGICAL ANALYSIS
FOR DARTMOUTH COVE OUTFALL, 1985

M O N T H	STATION	TOTAL COLIFORMS (per 100 ml)	FECAL COLIFORMS (per 100 ml)	TOTAL PLATE COUNT (per ml)	STAPHYLOCOCCUS (per 100 ml)	PSEUDOMONAS (per 100 ml)
A P R I L						
M A Y	1	> 3000	> 3000	TNTC	TNTC	0
	9	600	200	250	1000	0
	9A	70	14	450	100	0
	10	2500	200	200	6000	0
	10A	500	30	140	106	0
J U N E	9	600	600	800	1000	TNTC
	9A	600	200	800	200	400
	10	1000	700	1200	800	TNTC
	10A	90	70	1000	400	TNTC
J U L Y	1	> 3000	> 3000	TNTC	TNTC	0
	9	1040	880	300	TNTC	40
	9A	324	104	111	TNTC	0
	10	1000	920	340	TNTC	16
	10A	540	130	690	TNTC	20
A U G U S T	1	> 3000	> 3000	TNTC	TNTC	0
	9	4200	> 3000	TNTC	TNTC	300
	9A	1200	540	TNTC	120	600
	10	> 3000	> 3000	TNTC	TNTC	400
	10A	410	128	TNTC	TNTC	600

TABLE 5-20 RESULTS OF BACTERIOLOGICAL ANALYSIS
FOR SACKVILLE STREET OUTFALL, 1985

M O N T H	STATION	TOTAL COLIFORMS (per 100 ml)	FECAL COLIFORMS (per 100 ml)	TOTAL PLATE COUNT (per ml)	STAPHYLOCOCCUS (per 100 ml)	PSEUDOMONAS (per 100 ml)
A P R I L						
M A Y	1	> 3000	> 3000	TNTC	TNTC	0
	3	300	120	TNTC	260	100
	3A	200	40	TNTC	TNTC	0
	4	144	30	420	116	120
	4A	40	16	550	82	0
J U N E	1	1500	> 3000	TNTC	TNTC	10
	3	1300	1200	TNTC	1370	0
	3A	850	14	1760	760	350
	4	3800	2000	TNTC	2200	500
	4A	250	0	TNTC	TNTC	TNTC
J U L Y	1	> 3000	> 3000	TNTC	TNTC	TNTC
	3	1600	1200	34	TNTC	0
	3A	1000	40	100	TNTC	300
	4	1600	900	150	TNTC	10
	4A	16	8	54	320	46
A U G U S T	1	> 3000	> 3000	TNTC	TNTC	0
	3	900	112	270	150	24
	3A	880	360	190	300	8
	4	> 3000	> 3000	220	TNTC	22
	4A	620	0	91	540	50

TABLE 5-21 RESULTS OF BACTERIOLOGICAL ANALYSIS
FOR THE PIER A OUTFALL, 1985

M O N T H	STATION	TOTAL	FECAL	TOTAL	STAPHYLOCOCCUS	PSEUDOMONAS
		COLIFORMS (per 100 ml)	COLIFORMS (per 100 ml)	PLATE COUNT (per ml)	(per 100 ml)	(per 100 ml)
A P R I L	1	> 3000	> 3000	TNTC	TNTC	TNTC
	2	1500	1420	190	200	0
	2A	168	62	450	180	12
	3	2060	1660	180	160	80
	3A	128	20	26	800	22
	4	> 3000	> 3000	TNTC	TNTC	0
	5	2000	820	TNTC	500	4
	5A	84	6	45	180	140
M A Y						
J U N E	1	TNTC	> 3000	TNTC	TNTC	0
	2	3000	3000	TNTC	TNTC	0
	2A	TNTC	850	21	1800	0
	4	TNTC	> 3000	TNTC	TNTC	0
	5	920	300	137	330	470
J U L Y	1	> 3000	> 3000	TNTC	TNTC	46
	2	2400	2000	TNTC	TNTC	0
	4	> 3000	> 3000	TNTC	TNTC	70
	6	> 3000	> 3000	TNTC	TNTC	40
	6A	1000	400	240	TNTC	0
A U G U S T	1	> 3000	> 3000	TNTC	TNTC	0
	2	> 3000	> 3000	550	TNTC	20
	2A	1600	104	550	TNTC	20
	4	> 3000	> 3000	TNTC	TNTC	0
	6	3000	> 3000	TNTC	TNTC	4
	6A	400	60	TNTC	TNTC	152

TABLE 5-22 RESULTS OF BACTERIAL ANALYSIS FOR REFERENCE STATIONS FOR
HALIFAX HARBOUR, SPRING 1985

M O N T H	STATION	TOTAL	FECAL	TOTAL	STAPHYLOCOCCUS	PSEUDOMONAS
		COLIFORMS (per 100 ml)	COLIFORMS (per 100 ml)	PLATE COUNT (per ml)	(per 100 ml)	(per 100 ml)
	2	114	54	1000	18	80
	2A	14	0	6	30	160
	5	56	0	350	700	800
	5A	18	2	300	18	12
	6	190	2	300	20	30
	6A	100	0	300	4	400
	8	470	4	260	100	400
	14	170	4	170	670	1200
	14A	20	0	54	60	40

TABLE 5-23 RESULTS OF BACTERIAL ANALYSIS FOR REFERENCE STATIONS FOR
HALIFAX HARBOUR, SUMMER 1985

M O N T H	STATION	TOTAL	FECAL	TOTAL	STAPHYLOCOCCUS	PSEUDOMONAS
		COLIFORMS (per 100 ml)	COLIFORMS (per 100 ml)	PLATE COUNT (per ml)	(per 100 ml)	(per 100 ml)
	2	1200	420	46	400	18
	2A	1200	1200	45	1000	40
	5	1860	1160	78	68	12
	5A	940	260	113	356	30
	6	1100	500	TNTC	480	20
	6A	> 3000	> 3000	TNTC	TNTC	36
	8	> 3000	500	38	38	66
	8A	2000	260	TNTC	70	0
	14	58	4	49	72	52
	14A	4	0	340	6	168

"The evidence points to the fact that Coliform pollution is carried from the Harbour to the Basin" (Freeman 1972). This level was observed to be higher in summer than in spring. This fluctuation could have been caused by the seasonal freshwater runoff from the Basin watershed area. Bacteriological results indicate an "outspill" of Faecal Coliform, Staphylococcus and other sewage-originated microorganisms at the entrance to the Harbour. The quantity of this emanation has not been measured for Halifax Harbour.

The significance of contaminant transportation from raw sanitary and industrial wastewater lies in the uptake of the pollutants by fish and shellfish. Presently, there are 150 licensed fishermen (each with 3 or 4 licenses) actively involved in commercial fishing in Eastern Passage and the entrance to Halifax Harbour. A reported sum of 2,907 metric tons of fish is being caught within 100 feet of the shoreline (as reported by Fisheries and Ocean). The reported amount of catch has been estimated to be a small percentage of the actual amount being sent to market (Table 5-24).

Table 5-24: The statistics of fishing inshore in the vicinity of Eastern Passage and entrance to Halifax Harbour for 1984-1985.

		Groundfish	Pelagic & Estuarial	Shellfish	District
Eastern Passage	1984	668	1002	31	1701
	1985	540	648	18	1206
Entrance to Halifax Harbour	1984	88	53	13	153
	1985	51	14	95	160

There has been no monitoring program conducted to quantify the possible impacts of organic and bacterial transport on fishing, but there is a need for a qualitative measure. The results obtained by this study are not adequate in indicating possible impacts.

Section 5.2 Analysis and Discussion of the Seasonal Averages for the Field and Laboratory Data

The interpretation of the seasonal data for the most part has already been included in the subsections of Section 5.1. However, the comparative analysis of the seasonal averages provides a more comprehensive understanding of the time dependency of the contaminant concentrations and variation, in removal rate resulting from seasonal changes of water circulation. The importance of temporal variations on biochemical activities is also considered by analyzing the seasonal averages.

5.2.1 Temperature

Tufts Cove

The seasonal averages are illustrated in Tables C.1.1 to C.1.4 of Appendix C. Review of figures 5.2.1 and 5.2.2 indicates that summer temperatures were approximately 10°C greater than winter and spring values; the latter two varied only by a few degrees centigrade. The temperature distribution was more uniform in the surface waters than the bottom waters and did not correlate well in their distribution pattern. In summer, there was a stronger seasonal dependency of thermal variation in Tufts Cove. However, the shallowness of the Cove effected the water column and induced the presence of a narrower range of vertical variation. In comparison with the reference sites the Cove waters were warmer in every season.

Duffus Street

Seasonal averages of the field data are illustrated in Tables C.2.1 to C.2.4 of Appendix C. Review of figures 5.2.3 and 5.2.4 shows that summer temperatures were higher by 3 to 10°C, while spring and winter temperatures varied by less than 3°C. Initial sewage temperature at the point of discharge was greater than the plume waters in Duffus Street indicating a better dilution rate at this outfall site than Tufts Cove. Both horizontal

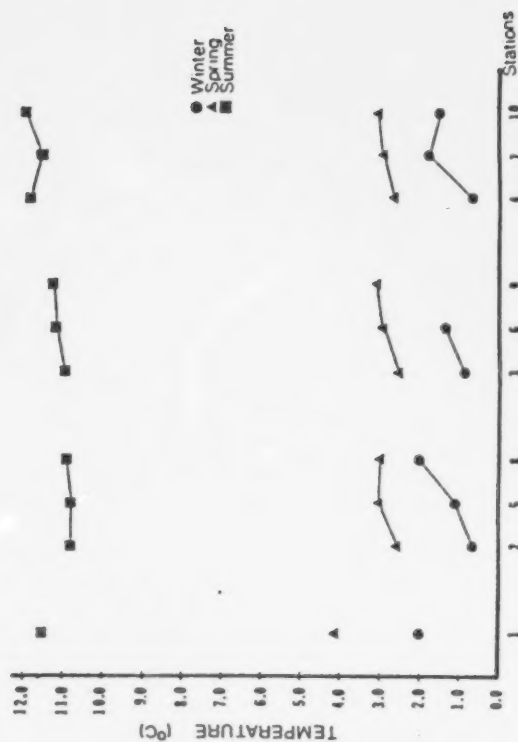


FIG 5.2.3 SEASONAL AVERAGES OF TEMPERATURE °C FOR THE SURFACE STATIONS AT DUFFUS STREET, 1984-1985.

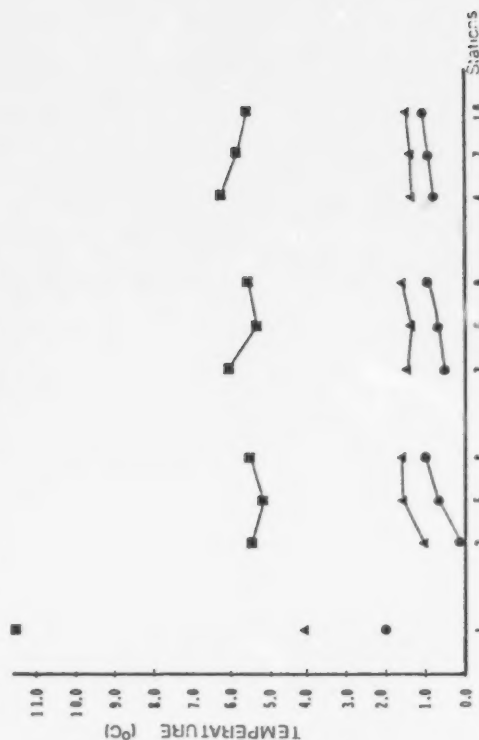


FIG 5.2.4 SEASONAL AVERAGES OF TEMPERATURE °C FOR THE BOTTOM STATIONS AT DUFFUS STREET, 1984-1985.

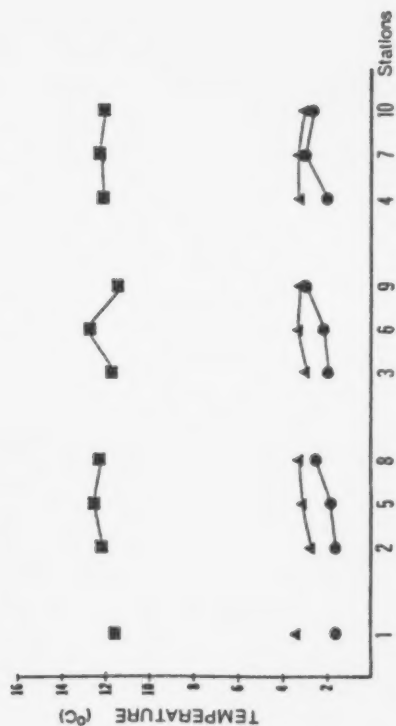


FIG 5.2.1 SEASONAL AVERAGES OF TEMPERATURE FOR THE SURFACE STATIONS AT TUFTS COVE, 1984-1985.

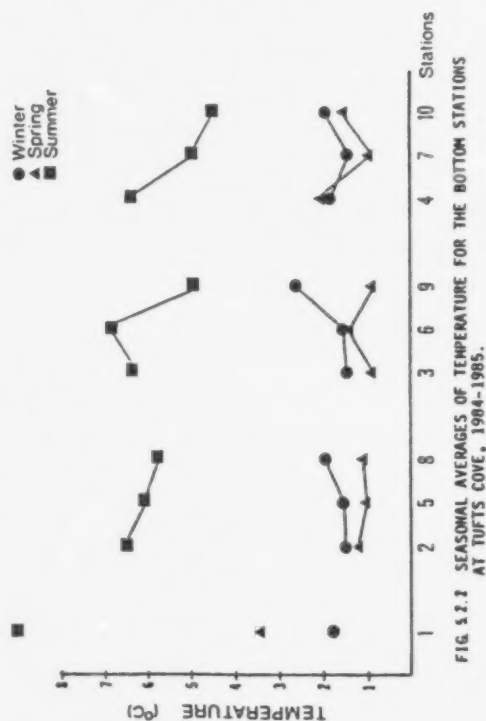


FIG 5.2.2 SEASONAL AVERAGES OF TEMPERATURE FOR THE BOTTOM STATIONS AT TUFTS COVE, 1984-1985.

and vertical distribution patterns were uniform. Therefore, it is clear that the temperature loss of the sewage in these waters was the result of a greater initial dilution. There was a greater thermal variation in this water column, resulted from the depth of these waters. The reference values were comparable with the seasonal averages.

Dartmouth Cove

Seasonal field averages are presented in Tables C.3.1 to C.3.4 of Appendix C. The summer values were higher than other seasons by 5-12°C, which was a wide range of variation. The spring and winter had thermal variation of less than 2°C. At certain stations the depth variability within the water columns accounted for a closer range of thermal variations between surface and bottom waters at certain stations; also, this variability was responsible for a very erratic thermal distribution pattern in both the horizontal and vertical directions. A comparative analysis of this data with the reference values emphasized, that the deeper sections of the Cove experienced similar temperature ranges, while the shallower sections were more susceptible to climatic changes, hence cooler in the winter and warmer in the late spring and summer.

Sackville Street:

Seasonal field averages are presented in Tables C.4.1 to C.4.4 of Appendix C. A review of the data indicates that summer values were 4-8°C higher than winter and spring, while spring water temperatures were warmer by less than 3°C of the winter readings. Thermal variation within the water column and throughout the plume waters was more pronounced in the summer. The accessibility and depth of this outfall site should have resulted in similar temperature ranges in both the plume and reference waters. However, this condition only existed in the summer time, while winter and spring temperatures of the plume waters were unusually colder than the reference sites. Storm runoff could account for daily or monthly variations but overall seasonal averages could not be hindered by this condition.

Pier "A"

Seasonal field averages for the two discharge points are presented in Tables C.5.1 to C.5.4 of Appendix C. The analysis of this data indicates that the erratic horizontal temperature variation existed throughout the Pier area in every season. The vertical thermal variation was seasonally dependent only in the stations outside Pier "A". In comparison to the reference values, the seasonal temperature of the Pier waters did not show a constant behaviour.

5.2.2 Dissolved Oxygen

Tufts Cove

The seasonal averages of DO are presented in figures 5.2.5 and 5.2.6, the corresponding data is contained in Tables C.1.1 to C.1.4. The greatest amount of Dissolved Oxygen occurred in spring while the values of the other seasons were low and similar range. The stations extending towards the NSPC had the same level of DO in fall, winter and summer. The lowest available oxygen was present in stations 2, 3 and 4, that was located in northern shallow section of the Cove, emphasizing the fact that contaminants accumulated in this area. In general, there was a very small variations in DO readings between the 100 and 150 meter stations.

The bottom stations had a very different distribution pattern than the surface station; with the bottom stations showing a clear seasonal dependency. However, the concentration of DO in the water columns was relatively constant. Dissolved Oxygen of the spring references were in the same range as Tufts Cove, otherwise the Cove waters had lower DO content than the reference sites during fall, winter and summer.

Duffus Street

Tables C.2.1 to C.2.4 of Appendix C contain the seasonal averages of dissolved oxygen and figures 5.2.7 and 5.2.8 illustrate the graphic

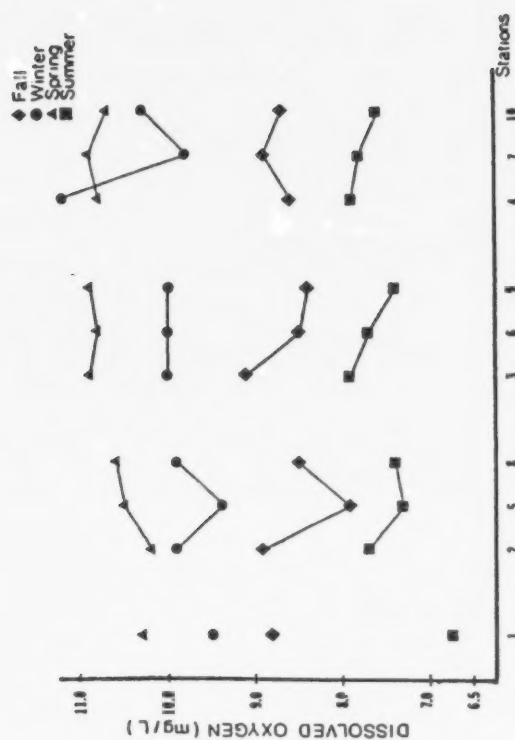


FIG 5.2.7 SEASONAL AVERAGES OF DISSOLVED OXYGEN FOR THE SURFACE STATIONS AT DUFFUS STREET, 1984-1985.

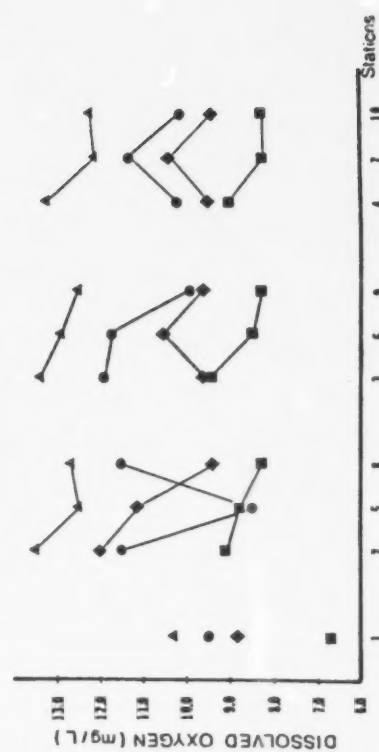


FIG 5.2.8 SEASONAL AVERAGES OF DISSOLVED OXYGEN FOR THE BOTTOM STATIONS AT DUFFUS STREET, 1984-1985.

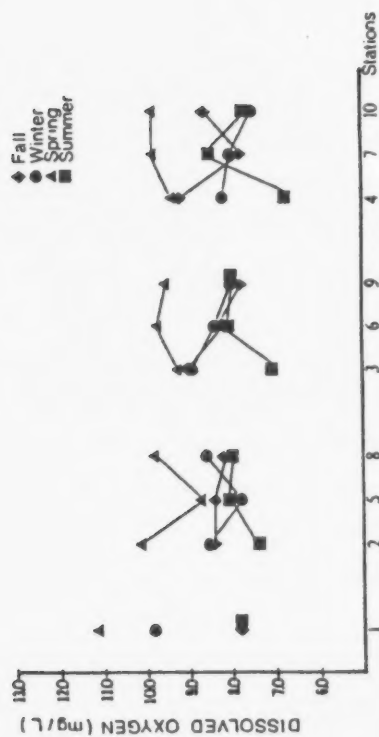


FIG 5.2.5 SEASONAL AVERAGES OF DISSOLVED OXYGEN FOR THE SURFACE STATIONS AT TUFTS COVE, 1984-1985.

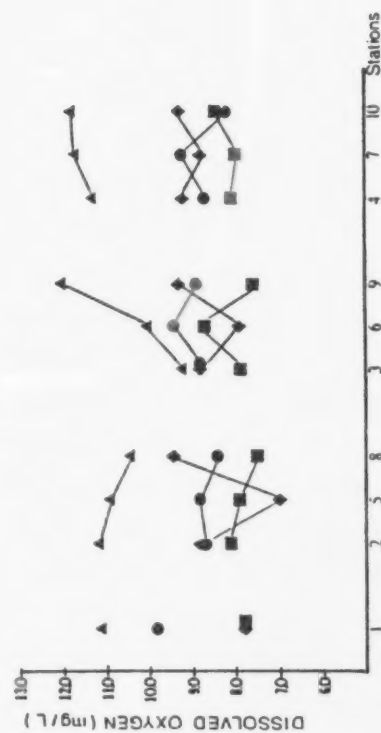


FIG 5.2.6 SEASONAL AVERAGES OF DISSOLVED OXYGEN FOR THE BOTTOM STATIONS AT TUFTS COVE, 1984-1985.

representation of the data. The DO levels of this area were clearly higher than Tufts Cove. The pattern of DO variation indicated an increase in values from winter to spring, and an overall decrease from fall 1984 to summer 1985. Seasonal values of DO at the point of discharge appear to be in the same range or slightly lower than other stations.

According to the seasonal data there was higher concentrations of available oxygen in the bottom stations than surface stations. A comparative analysis of the data indicated similar dissolved oxygen concentrations in the reference sites and the plume waters in every season, except summer.

Dartmouth Cove

Review of Tables C.3.2 to C.3.4 of Appendix C results in the following observations. Dissolved oxygen in the surface waters seldom surpassed or fell below 10.0 mg/L and these values were in the same range as the DO at the point of discharge. The water columns had a better indication of vertical DO variation in spring and summer, while the horizontal variation existed in every season.

The bottom waters appeared to have depleted DO levels in summer. There were elevated levels of oxygen available during winter and spring. During fall the water columns were well mixed, and showed an erratic distribution pattern both in the surface and bottom waters. Analysis of the data indicated that the DO levels of the plume waters were the same as the reference waters.

Sackville Street

The seasonal averages of the field data is presented in Tables C.4.2. to C.4.4 of Appendix C. The plume waters had low DO readings during summer. The surface waters showed a constant depletion within the first 50 meters during every season. The horizontal and vertical distribution of DO values were erratic with an exception for summer.

There was a clear sign of an increase in DO content of the waters from surface to bottom. Dissolved oxygen content of the bottom waters were very

high during spring, while the lowest surface dissolved oxygen was also observed in this season. The oxygen content of the reference waters were lower than the plume waters during spring while the summer values were higher.

Pier "A"

A review of Tables C.5.2 to C.5.4. of Appendix C indicates a very erratic dissolved oxygen distribution pattern in these outfall waters. The seasonal surface oxygen content of the surface waters in between the stations, did not increase or decrease with any consistency. The vertical distribution pattern was equally inconsistent.

The highest bottom values were observed in spring regardless of the DO content of the sewage. Comparison of the seasonal values and the reference values DO indicated no clear correlation.

5.2.3 Salinity

Tufts Cove

Seasonal averages of the salinity data are presented in Tables C.1.1 to C.1.4 of Appendix C, and the graphic illustrations of this data are in figures 5.2.9 and 5.2.10.

This data indicated a definite seasonal variation yet a uniform distribution pattern of salinity values. The wastewater at the point of discharge had salinity readings of 27.5, 29.1 and 24.5 g/kg for winter, spring and summer, accordingly. The salinity of the surface waters were also higher in the spring than in winter and summer, and followed a similar trend of salinity changes throughout the Harbour.

The surface distribution pattern remained unchanged for the upper 3 meters of the Cove waters. From the 3 meter depth to the bottom of the water column the salinity distribution was erratic. The spring and winter bottom values remained in the same range as the surface waters, while in the summer bottom

waters had 4.0 to 6.0 g/kg higher salinity content indicating the existence of stratified and denser waters within the depth of 4 to 6 meters of stations 8, 9 and 10. The stratification of the reference waters occurred in spring and the depth of the stratified layer was a shallow 2-4 meters. The winter values also showed a well mixed water column with salinity values in the range of 27.0 to 29.0 g/kg.

In general, the Cove waters had 1.0 to 2.0 g/kg less salinity content than the waters of Duffus Street indicating a moderate dilution rate with Harbour waters. Comparative analysis of this data with the references shows lower salinity in the Cove than those in the references, which also emphasized the containment of sewage in the Cove.

Duffus Street

Seasonal averages are presented in Tables C.2.1 to C.2.4 of Appendix C. Figures 5.2.11 and 5.2.12 show the graphic illustration of the data.

Salinity of the sewage at the point of discharge was 25.5, 22.0 and 19.1 g/kg for winter, spring and summer, respectively. The sewage had between 4.0 and 10.0 g/kg less saline content than the rest of the plume waters, and indicating a good level of initial dilution of the wastewater. The salinity of the surface waters were higher in spring; with the winter and summer values following.

The uniform pattern of salinity distribution of the surface waters did not extend to the bottom waters. Seasonal salinity variation of the bottom waters was less than that of the surface waters; during winter and summer the bottom waters had the same salinity range of 29 to 31 g/kg.

Hydrodynamic superceding of the wastewater on the seawater was evident. Another density gradient lead to the stratification of these waters which was observed in the summer; while reference stations were stratified in late spring. The depth of the stratified layer was 2-4 meters which was shallower than that of the reference stations.

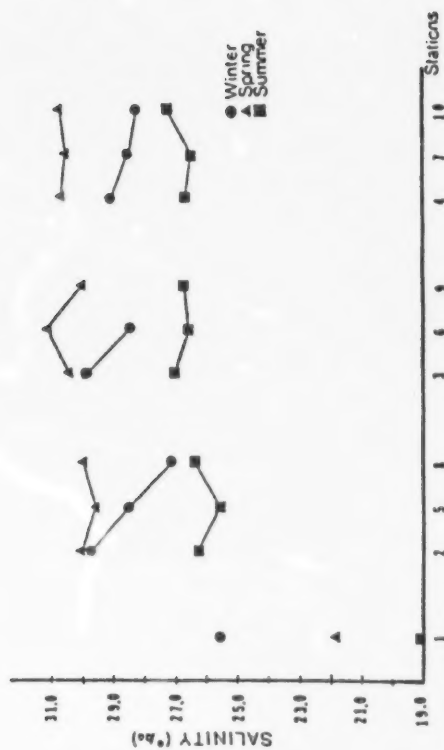


FIG. 5.2.11 SEASONAL AVERAGES OF SALINITY (‰) FOR THE SURFACE STATIONS AT DUFFUS STREET, 1984-1985.

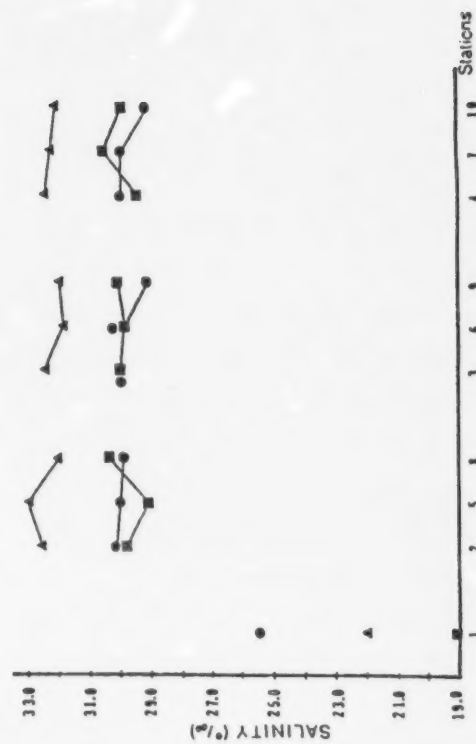


FIG. 5.2.12 SEASONAL AVERAGES OF SALINITY (‰) FOR THE BOTTOM STATIONS AT DUFFUS STREET, 1984-1985.

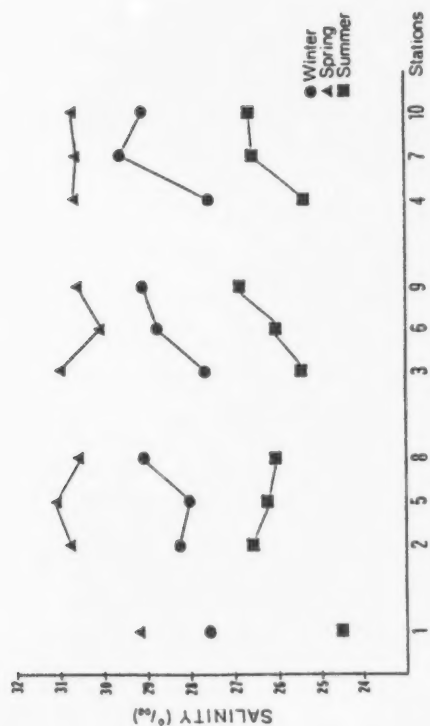


FIG. 5.2.9 SEASONAL AVERAGES OF SALINITY FOR THE SURFACE STATIONS AT TUFTS COVE, 1984-1985.

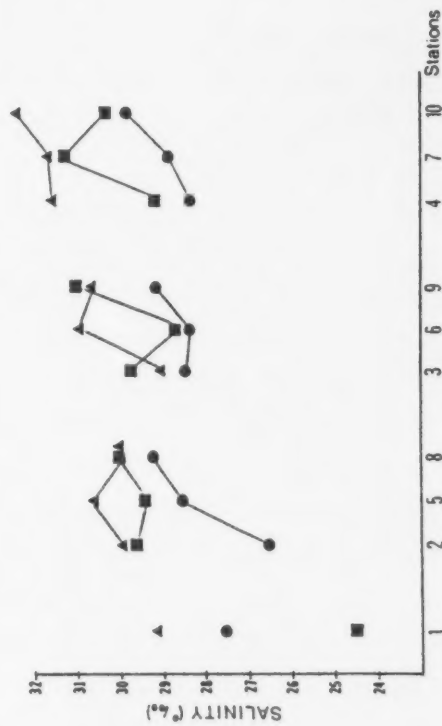


FIG. 5.2.10 SEASONAL AVERAGES OF SALINITY FOR THE BOTTOM STATIONS AT TUFTS COVE, 1984-1985.

Dartmouth Cove

Seasonal field data are presented in Tables C.3.1 to C.3.4 of Appendix C.

The salinity of the sewage at the point of discharge for winter, spring and summer was in a narrow range of 25.0 to 26.8 g/kg. The surface of the Dartmouth Cove waters showed override of sewage; this condition was more evident in spring. The spring salinity values were 1.0 to 2.0 g/kg higher than the winter and summer values.

The erratic distribution pattern of the salinity in subsurface waters was more pronounced in the stations less than 5 meters deep; hence the shallowness of the Cove had a significant impact on the salinity. Generally, the water columns of each station were uniformly mixed in winter while during the other seasons highly saline waters concentrated in the bottom waters.

Stratification of the Cove waters was apparent during the summer months with a shallow stratified layer of 2-4 meters, while the stratified layer of the reference sites was at the depth of 6-8 meters. The salinity gradient in these waters resulted from a range of 25.0 to 32.8 g/kg values. In comparison, the salinity of the Cove waters was less than the reference site, specifically for stations within 100 meters of the discharge point.

Sackville Street

Seasonal field averages are illustrated in Tables C.4.2 to C.4.4 of Appendix C.

Sewage emanating from this outfall had salinity values of 26.4, 27.2 and 25.6 g/kg for winter, spring and summer. The spring salinity values were higher than the summer and winter readings. The surface override of sewage was pronounced during every season. Distribution pattern of salinity on the surface of the Cove was uniform.

The water column of each station also had a uniform distribution pattern. The bottom waters had slightly greater (0.1 to 2.0 g/kg) salinity readings than the surface waters. Better mixing of the columns was apparent in stations 4 and 6, located outside the wharves.

Winter values of salinity showed a well mixed water column. The salinity gradient started in spring and became deeper and more pronounced in summer. The 2-4 m depth of the stratified layer was shallower than the reference stations. However, the salinity values were comparable. The depth of this outfall (10-17 meters) enhances the initial dilution as well as continuous mixing of the sewage with Harbour waters.

Pier "A"

Tables C.5.2 to C.5.4 of Appendix C contain the seasonal field averages of salinity.

The average salinity values of 27.9, 25.0 and 19.5 g/kg were present at the tunnel discharge point during winter, spring and summer. The overflow pipe had lower salinity values of 26.0, 23.7 and 22.7 g/kg for the same seasons. This condition indicated a low initial dilution at plume 2 or slightly higher flow rates at this discharge point. Both plume waters of this outfall site showed a variable level of surface override of sewage.

Vertical mixing of sewage was apparent in the plume 1 area. Hence, the bottom salinity distribution also indicated higher salinity readings in spring than in summer and winter, with a similar distribution pattern as the surface waters.

The stratification of the Pier waters was not as apparent as those outside. The waters of stations 5 and 6 had a stratified layer at the depth of 3-4 meters in summer. The salinity readings for stations 5 and 6 as well as the depth of the stratified layer were comparable to reference sites.

5.2.4 Conductance

Tufts Cove

Tables C.1.1. to C.1.4 of Appendix C present the seasonal averages of this parameter. The illustrative presentation of the data are in figures 5.2.13 and 5.2.14.

Conductivity of the wastewaters at the point of discharge was 25,000 to 35,000 $\mu\Omega$ /cm less than the stations. Surface waters had lower conductance in spring than in summer. Distribution patterns of the surface and bottom waters of the 150 meter stations were similar in spring, otherwise the conductivity of the water columns were dissimilar, indicating a lack of vertical mixing. However, the conductivity of the surface waters was higher by 10,000-15,000 $\mu\Omega$ /cm than the bottom stations.

The reference values were comparable with spring readings of the outfall site, and 2,000 units greater during the summer months.

Duffus Street

Tables C.2.1 to C.2.4 of Appendix C contain the seasonal averages of conductivity. The illustrative presentation of the data are in figures 5.2.15 and 5.2.16.

The wastewater at the point of discharge had a conductance of 21,000 and 22,000 $\mu\Omega$ /cm which was lower by 6,000 to 10,000 units from the readings of the stations. This condition showed uniform horizontal and vertical mixing pattern of sewage with the seawater, and indicate a high level of water circulation within the area. However, the conductance of the plume waters was always lower than the reference station, indicating the introduction of fresh wastewater. The conductivity of the stratified layers, in both waters, was different. The dense, saline waters of the bottom stations had slightly lower conductivity readings than that of the less saline surface waters.

Dartmouth Cove

Tables C.3.1 to C.3.4 of Appendix C contain the conductivity data for this outfall site.

Conductivity of the sewage at the point of discharge was in the range of 22,530 and 28,730 $\mu\Omega$ /cm during spring and summer, respectively. The water columns of the Cove were not mixed, hence during the spring the conductivity increased from the surface to the bottom, but this trend was reversed in summer. The stations within 100 meters of the point of discharge had similar

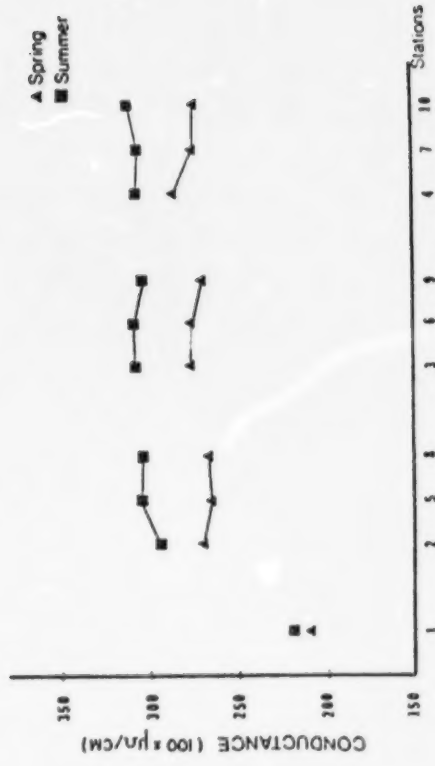


FIG-5.2.15 SEASONAL AVERAGES OF CONDUCTANCE FOR THE SURFACE STATIONS AT DUFFUS STREET, 1984-1985.



FIG-5.2.16 SEASONAL AVERAGES OF CONDUCTANCE FOR THE BOTTOM STATIONS AT DUFFUS STREET, 1984-1985.

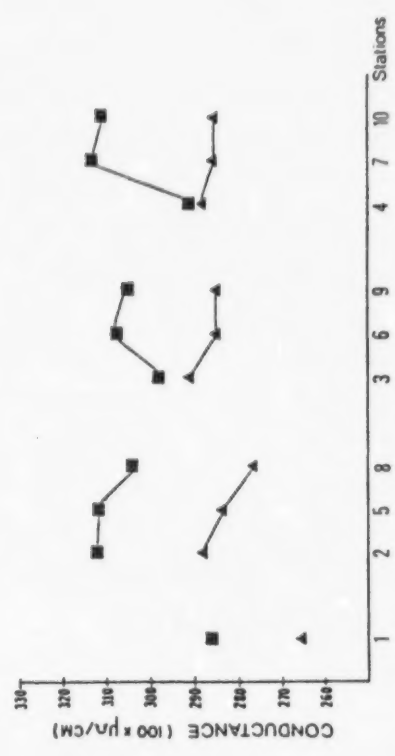


FIG-5.2.13 SEASONAL AVERAGES OF CONDUCTANCE FOR THE SURFACE STATIONS AT TUFTS COVE, 1985.

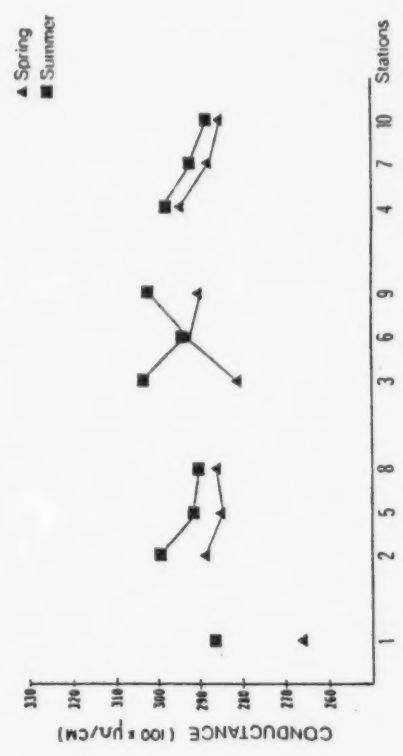


FIG-5.2.14 SEASONAL AVERAGES OF CONDUCTANCE FOR THE BOTTOM STATIONS AT TUFTS COVE, 1985.

conductivity values as that of discharge points, showing the superceding of the sewage on the seawater. A comparison between the conductivity readings of the Cove and reference waters shows that the Cove waters behaved so irregularly that in each depth and season the correlation was entirely different.

Sackville Street

Seasonal averages of conductivity has been tabulated in Appendix C, Tables C.4.2 to C.4.4.

The conductivity of the sewage at the point of discharge was 31,500, 25,330 and 29,580 $\mu\Omega$ /cm in winter, spring and summer, accordingly. Plume waters had the highest conductance in winter followed by summer and spring. The water column had uniform conductivity readings in winter, while these readings increased from the surface to the bottom of the water column. Summer values were in reverse order of those in spring. The conductivity of surface water was lower than at the bottom, indicating the hydrodynamic override which only existed within the first 50 meters of the plume waters. However, the plume waters generally had lower conductivity readings than the reference stations indicating the continuous introduction of freshwater into the area. The general characteristics of the stratified layer were similar to that encountered in Duffus Street plume waters.

Pier "A"

Tables C.5.2 to C.5.4 of Appendix C contain the seasonal averages of the field data.

The conductivity values of the sewage from the tunnel discharge point were 39,000, 24,520 and 23,200 $\mu\Omega$ /cm, while the overflow pipe emanated sewage with higher conductivity of 37,000, 23,860 and 25,330 for each respective season. The highest conductivity in the plume waters was observed in winter followed by summer and spring. The plume waters were well mixed throughout the areas of both discharge points. During spring the water column had a very irregular distribution pattern and this condition was also evident in summer. A comparison of this data with the reference readings shows 1,000 to 7,000 lower conductivity for the plume waters. The condition of conductivity in relation to the stratified layer was not evident for Pier "A".

5.2.6 Chemical Oxygen Demand

Tufts Cove

The seasonal laboratory averages are presented in Table D.1.1 of Appendix D, and the graphic illustration of the data is in Figure 5.2.17.

The concentrations of 284.0 and 609.0 mg/L of Chemical Oxygen Demand at the point of discharge was 180% more than 217.7 mg/L extracted from manhole samples in spring; there was a 78% accumulation of COD present for the summer. There was an approximate 35-50% drop in the COD values within the first 50 meters, whereas, the chemicals were reduced at a rate of 3-12% within the next 100 meters of the plume waters. Chemicals accumulated at a rate of 40% from the 100 to 150 meter bottom stations during spring. Hence, within 150 meters of the monitored area the COD's were only reduced by a maximum of 53%.

Remaining COD's were transported to the middle of the Harbour during spring or to the Basin on incoming tide and towards MacNabs Island in an outgoing tide. They were reduced by another 30% from the 150 meter stations to the references during the summer.

Duffus Street

The seasonal laboratory averages of COD are presented in Table D.2.1 of Appendix D; and graphic illustration of the data is in figure 5.2.18.

The concentration of COD at the point of discharge was 149.9 and 157.3 mg/L which indicated a 12% accumulation from the manhole concentrations for spring. A COD reduction due to dilution of 16% during summer was evident. The average concentration of COD in this site was 50% of that in Tufts Cove waters. This is a substantial amount considering the population and the size of the tributary area for Duffus Street. There was a net

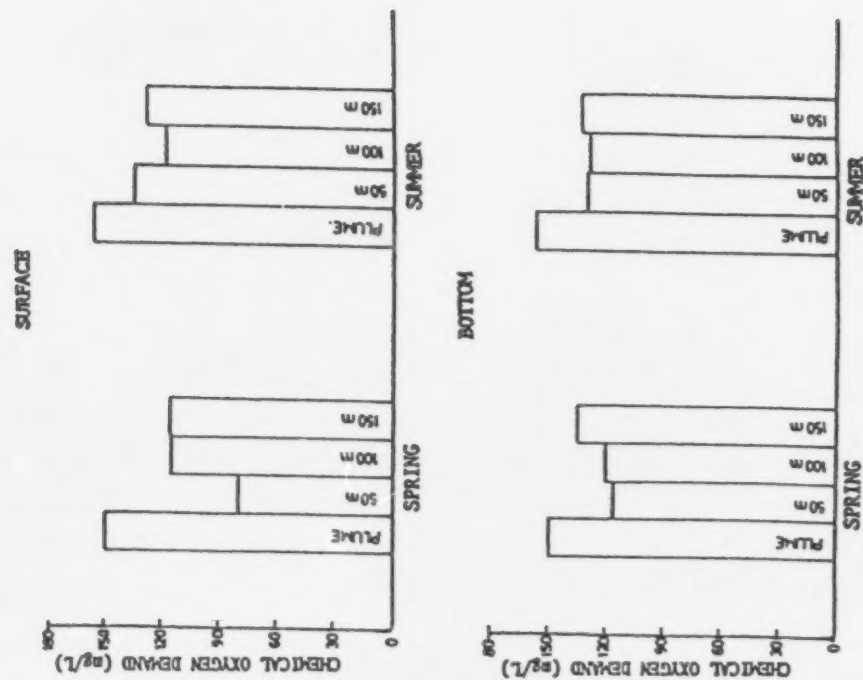


FIG. 5.2.17 SEASONAL AVERAGES OF CHEMICAL OXYGEN DEMAND (mg/l) FOR TUFFS COVE, 1985.

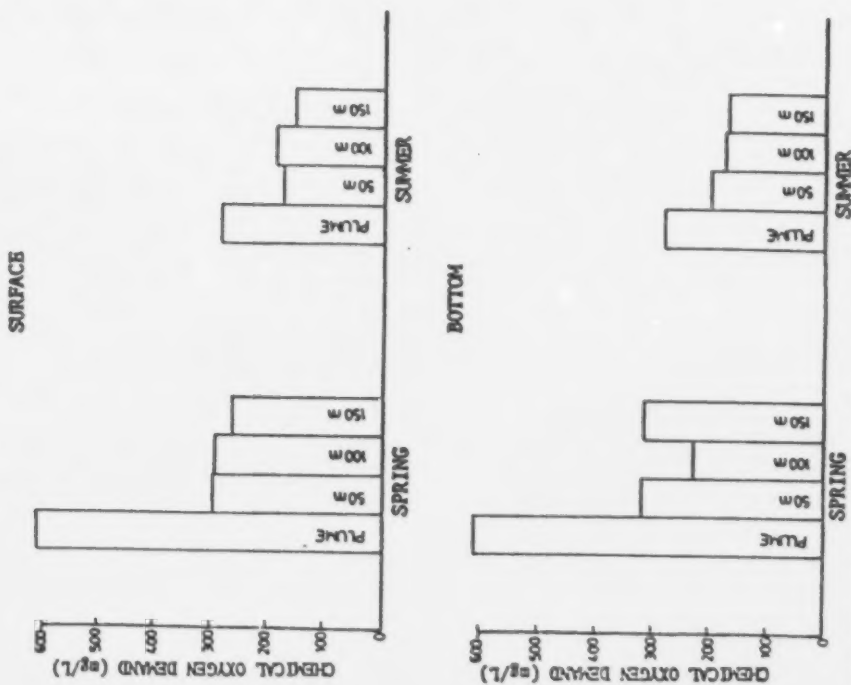


FIG. 5.2.18 SEASONAL AVERAGES OF CHEMICAL OXYGEN DEMAND (mg/l) FOR DUFFUS STREET, 1985.

chemical reduction of 14.5% to 40.4% within the first 50 meters of the plume waters for both seasons. Within the next 100 meters both in the surface and bottom stations chemicals were accumulating at a rate of 16.3 to 45.0%. The COD concentrations in the surface and bottom waters were comparable.

The remaining chemical oxygen demand was transported to the middle of the Harbour and accumulated at a rate of 38% in spring, and removed at a maximum rate of 83% during summer.

Dartmouth Cove

The seasonal averages of laboratory data are presented in Table D.3.1 of Appendix D.

Chemical oxygen demand concentrations from the point of discharge were 291.8 and 257.3 mg/L for spring and summer; these values showed a 34.5% to 40.3 percent reduction due to dilution from the COD concentrations detected from the manhole samples. Within the first 50 meters of the outfall the COD was reduced another 45.7 to 60.3% both at the surface and bottom waters. The percent reduction due to removal and possible oxidation was 0.7 to 27.1% within the next 150 meters of the plume waters. Therefore the greatest amount of reduction occurred from the manhole to the point of discharge due to dilution. From the 50 meters to the 150 meter stations of the plume waters there was not a substantial reduction in COD concentrations. Since the chemicals were reduced by 30% within 200 meters of the plume area.

In comparison with the COD concentrations of the plume waters the chemical content of the reference waters increased by up to 120% on the surface, while the bottom waters showed a 66 to 83% reduction of chemicals. Hence, the override of these chemicals was pronounced. A comparative study indicated that the chemicals of the other outfall sites also moved to the middle of the Harbour and were being transported northerly or southerly in the Harbour depending on the season.

The seasonal averages of chemical oxygen demand concentration are presented in Table D.4.1 of Appendix D.

An average reduction due to dilution of 55% in COD had been observed between the concentrations of the pollutants in the samples from the manhole and the discharge point. The concentration of the chemicals was reduced by another 5% within the first 50 meters of the plume waters and, this low reduction rate prevailed throughout the water columns.

Remaining contaminants were observed to be transported to the middle of the Harbour in the spring. In the summer the COD's decreased by 80% from the plume waters to the reference stations. Therefore, it was evident that in the Sackville Street plume waters, the initial dilution was the predominant mechanism of chemical oxygen demand reduction, and the removal of the contaminants prevailed under certain conditions as those observed in summer.

Pier "A"

The seasonal averages of COD concentrations are presented in Table D.5.1 of Appendix D.

A low 30% percent reduction due to dilution was present between COD concentrations of the manhole and discharge points samples. In the first 200 meters from the tunnel sanitary sewer, the average COD concentration decreased by 40%; within the next 300 meters of the plume waters the chemical removal and reduction was +15%. Hence a low 30% reduction of COD contaminants prevailed within 600 meters of these plumes.

The bottom waters had higher COD concentrations within the plume waters than the surface waters in both seasons, this condition was not present at the reference sites. Remaining chemical contaminants were transported to the middle of the Harbour, indicating a 30% accumulation on the surface waters during spring. In general there was a low rate of chemical removal from the waters of Pier "A".

5.2.7 Biochemical Oxygen Demand

Tufts Cove

Seasonal averages of laboratory data for this outfall site are in Table D.1.2 of Appendix D and the graphic presentation of the data is illustrated in figure 5.2.19.

There was a 30 to 70% reduction of biochemical content from the manhole to the discharge point with exception for winter when there was a 300% accumulation of BOD. Within the first 50 meters of the plume waters a large 98-99% dilution and removal rate was present in fall and summer. This removal rate was 70 to 80% less within the next 100 meters of the plume waters. Nevertheless, the BOD values of the 50 meter stations were well below 20 mg/L in every season. The BOD readings of the bottom waters were well below 10 mg/L and indicated a faster dissipation of biodegradable contaminants as well as a strong override of sewage. An average drop of 50% in BOD concentrations from 150 meter stations to the reference sites, indicated a rapid precipitation and removal rate, which brought the readings of the references to 3.7 to 1.5 mg/L.

Duffus Street

The seasonal averages of the laboratory data for this outfall site are presented in Table D.2.2 of Appendix D and figure 5.2.20 is the graphic presentation of this data.

There was a 45% reduction due to dilution of BOD contaminants, from the manhole to the discharge point. The discharges of this outfall area were in the close range of 25.0 to 33.0 mg/L during every season. The percent reduction within the first 50 meters of the surface waters was observed to be 40 to 80%, while in the bottom waters the calculated reduction due to removal and dissipation was 70 to 90%. Hence, a better contaminant removal mechanism prevailed in the bottom waters of this outfall area. A range of 2.6 to 5.2 mg/L of BOD remained within 150 meters of plume waters; these values dissipated to 1.0 to 3.8 mg/L within the distance between the outfall and reference stations.

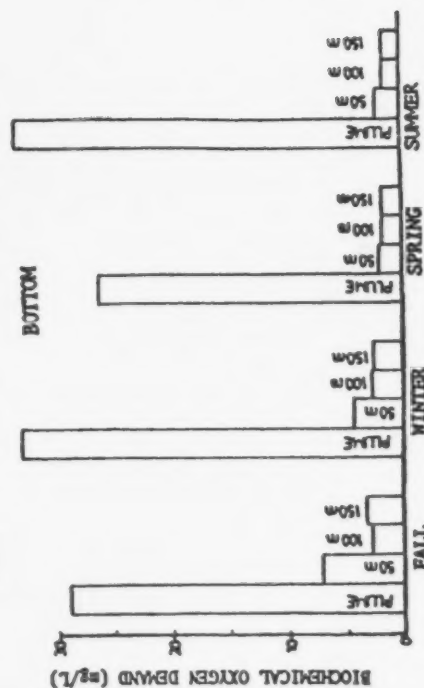
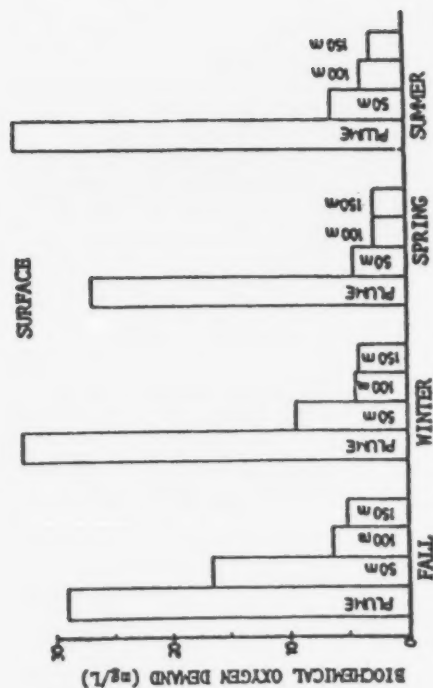


FIG 5.120 SEASONAL AVERAGES OF BIOCHEMICAL OXYGEN DEMAND (mg/l) FOR DUFFUS STREET, 1984-1985.

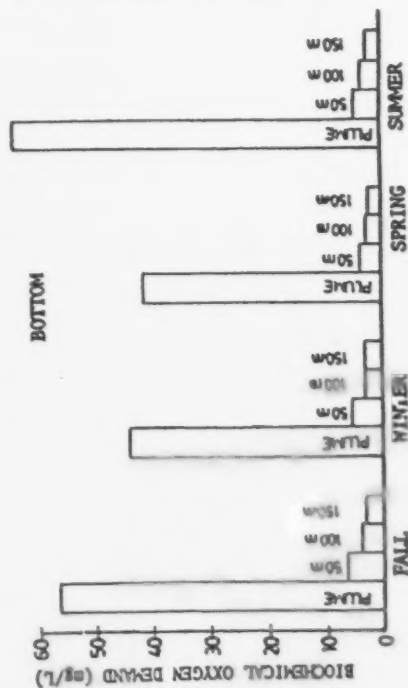
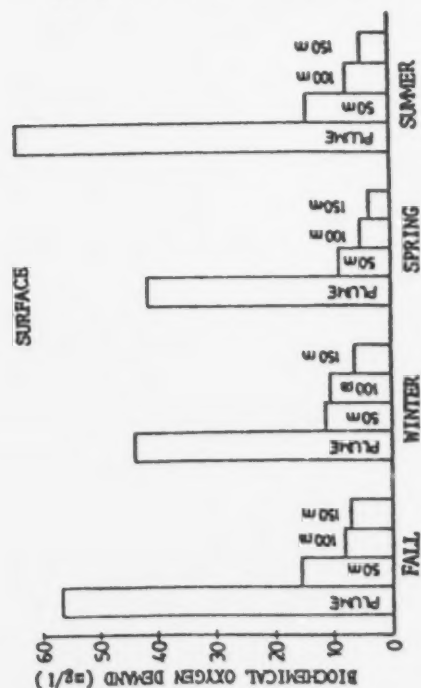


FIG 5.118 SEASONAL AVERAGES OF BIOCHEMICAL OXYGEN DEMAND (mg/l) FOR TUFTS COVE, 1984-1985.

Dartmouth Cove

Table D.3.2 of Appendix D contains the seasonal averages of the laboratory data for this outfall site.

The BOD concentrations of the manhole samples varied from 60.3 to 121.5 mg/L, seasonally. A variable 33 to 76% BOD reduction due to dilution was present between the manhole concentrations and those of the discharge point. During fall there was an accumulation of BOD within the first 50 meters at a rate of 11%; otherwise the biodegradable contaminants were being removed at an average rate of 75% within the first 50 meters. Within the next 100 meters the BOD concentrations reduced to 2.5 to 3.9 mg/L level which was in a similar range as 1.0 to 3.5 mg/L observed in reference sites.

Sackville Street

Table D.4.2 of Appendix D presents the seasonal averages of the laboratory data for this outfall site.

The BOD values at the Sackville Street outfall indicated an average drop of 84% due to initial dilution. A further 80% reduction decreased the BOD concentration at the 75 meter stations to a 3.9 to 6.6 mg/L range. These values remained relatively unchanged for another 100 meters, but they decreased to a 1.5 to 3.8 mg/L range in the middle of the Harbour. The dilution and, to a lesser extent, removal of the BOD contaminants appeared to dominate the BOD reduction processes in this site.

Pier "A"

Table D.5.2 of Appendix D contains the seasonal averages for laboratory data.

The concentrations of the biodegradable content of the sewage and the percent reduction due to dilution were observed to be seasonally dependent. During winter there was a higher BOD concentration in these waters than in spring. A drop in BOD concentration and an increase in initial dilution was characteristics of summer. The sharp decrease in summer BOD concentrations within both plume waters prevailed in the reference stations, too.

5.2.8 Suspended Solids

Tufts Cove

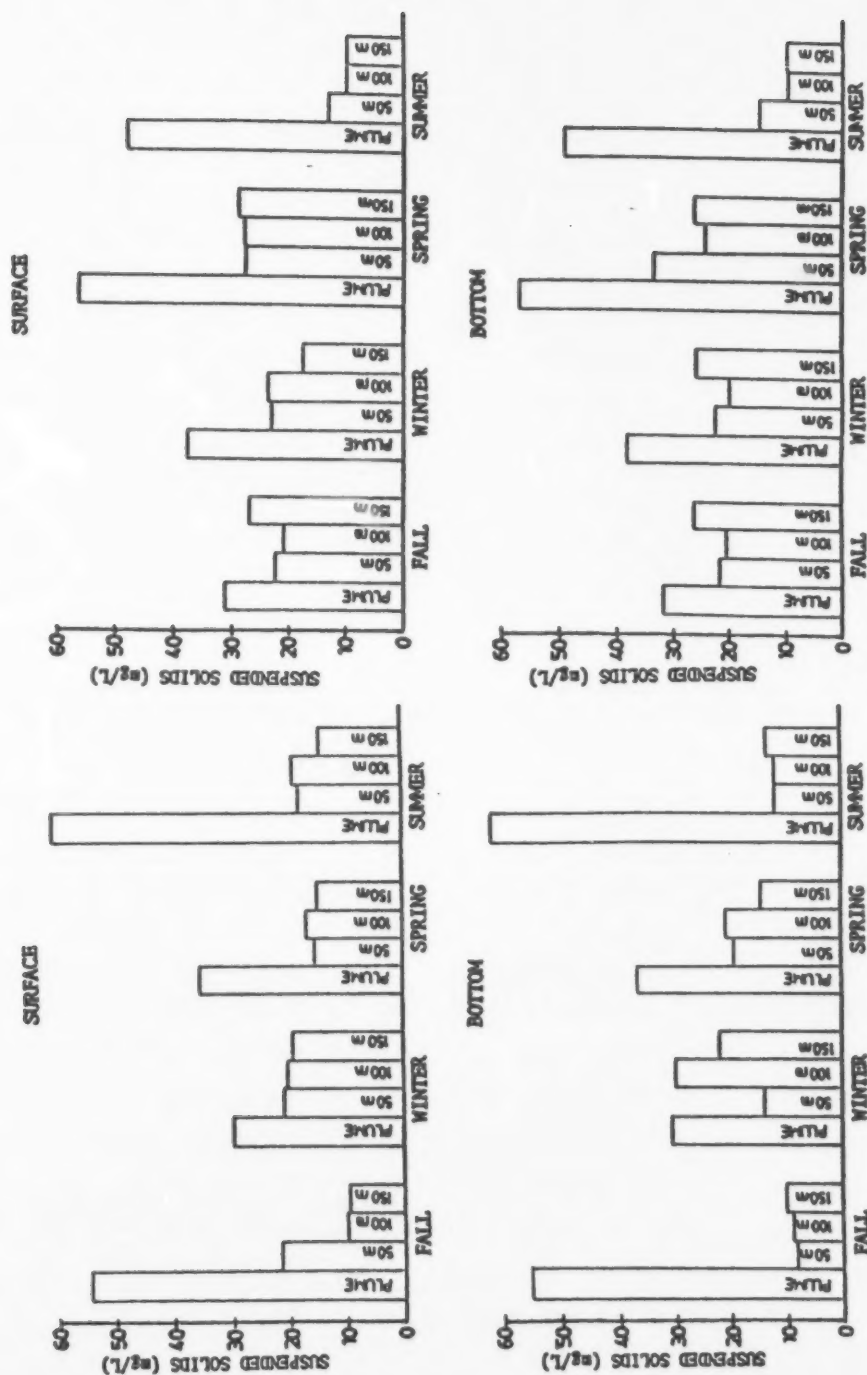
Seasonal averages of the laboratory data are presented in Table D.1.3 of Appendix D. The graphic illustration of the data is presented in figure 5.2.21.

Suspended solid content of the sewage at the manhole was low (55.9 mg/L) in summer and greater (120.0 mg/L) during winter and spring. An average reduction due to dilution of 45% was present in the winter and spring while a 9% accumulation occurred during summer. Within the first 50 meters from the point of discharge a variable reduction rate of 30 to 70% existed. In general the surface waters had higher suspended matters than the subsurface waters indicating an override of sewage on the Cove waters throughout the year. From the 50 to 150 meter stations, a very small amount of dissipation existed, except for fall. The suspended solid concentration of the 150 meter stations was very similar to the 6.2 to 33.0 mg/L readings observed in the middle of the Harbour.

Duffus Street

Seasonal averages of the laboratory data are presented in Table D.2.3 of the Appendix D. Figure 5.2.22 contains the graphic presentation of this data.

The manhole samples contained 47.6 to 56.5 mg/L of suspended matters. The reduction due to dilution was pronounced in the first 50 meters; except for the spring readings which showed a 20% accumulation of suspended solids. Within the water columns of the 50 and 100 meter stations, there was less vertical variation than that of the 150 meter stations, indicating better water movement through the deep waters of 150 meter stations of 4, 7 and 10. The concentration of the suspended solids was the same in the 150 meter stations and the adjacent stations in the middle of the Harbour.



Dartmouth Cove

Table D.3.3 of Appendix D contains the seasonal average of the laboratory data.

The suspended solid concentrations of the manhole samples were uniform and in the 80.0 to 100.0 mg/L range. A low 13 to 48% reduction due to initial dilution decreased the concentrations in winter and summer. The spring values showed an accumulation of the suspended matters in the Cove waters. The greatest reduction was in the first 50 meters of the plume waters; the 100, 150 and 200 meter stations had similar solid concentrations. The water columns contained slightly (10 to 20 mg/L) higher suspended matter concentrations in the bottom waters. The concentration of suspended solids in station 10 was within ± 10 mg/L of the reference sites. In general, during summer low suspended solids values were present, indicating better water circulation; this trend continued during fall.

Sackville Street

Table D.4.3 of Appendix D contains seasonal averages of the laboratory data.

The concentration of suspended solids in the waters of this outfall area were in a range of 19.6 to 61.2 mg/L, which showed an average of 40% reduction due to dilution from the manhole values. The summer readings were unusually high (1212.1 mg/L) resulted from an elevated concentration of suspended solids. Otherwise lower readings in the summer coincide with low percent reduction within the first 100 meters. During winter and spring the percent reduction within the first 100 meters of the plume waters was approximately 55%. The values of suspended solids were ± 20 mg/L higher at the bottom than at the surface. The concentration of suspended matters from the 150 meter station to the middle of the Harbour was altered, but it did not show any specific pattern of dissipation or accumulation.

Pier "A"

Table D.5.3 of Appendix D contains seasonal averages of the laboratory data.

Manhole samples had lower suspended solid concentrations during the spring and summer than the discharge point; thus a variable accumulation of 38 to 142% was observed in this outfall area for either season. During winter there was a 12% reduction due to dilution present in the plume waters of these two outfalls. There was a small percentage of suspended solid depletion in the winter, but in spring and summer the depletion increased to a 50-65% level. The stations around the plume of the overflow pipe showed a faster depletion of solids, indicating better accessibility of this plume. However, the concentration of suspended matters was lower at plume 2 than at the reference site, and the reference waters had comparable readings with plume 1, except in the summer.

5.2.9 pH

Tufts Cove

Table D.1.4 of Appendix D contains the seasonal averages of the laboratory data. Figures 5.2.23 illustrate the graphic presentation of this data.

The pH values at the point of discharge were lower than the other stations and the lowest readings were observed in winter. In general, the pH of the plume waters was being adjusted to those of the Harbour waters. Hence, a very small fluctuation of +1.0 pH unit was observed. This condition was evident for every season. Greater variations were present in daily and monthly values, than for the seasonal averages. The surface and bottom waters had variations of +1 unit or less. A comparison between the pH values at the plume and reference waters, showed a similar range of variation.

Duffus Street

Table D.2.4 of Appendix D contains the seasonal averages of pH data. The graph of figure 5.2.24 illustrates this data.

The pH readings at the point of discharge were 1.2 units lower than the other stations. The sewage emanating from this outfall had more uniform pH

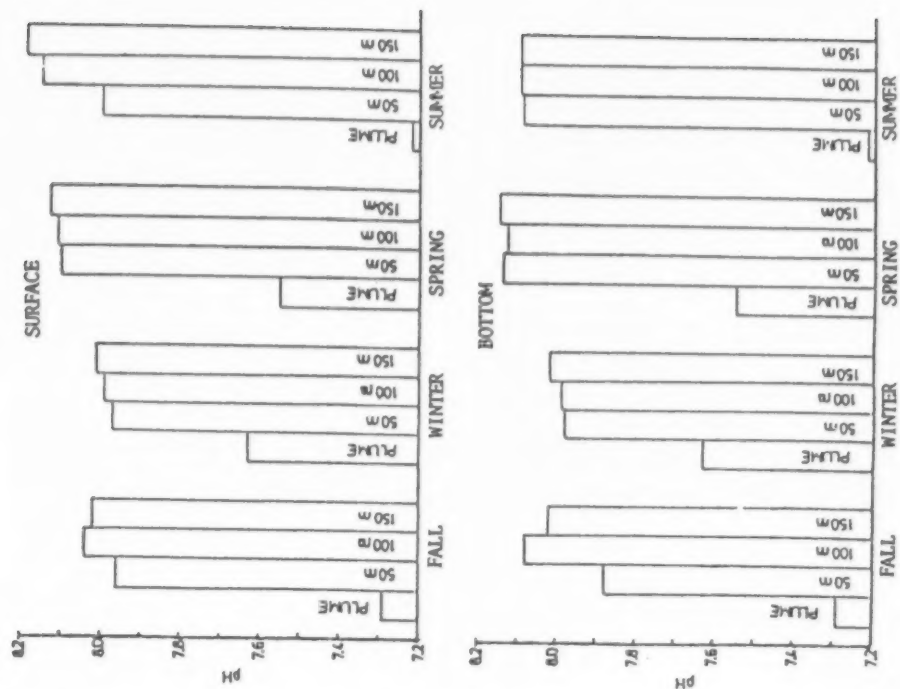


FIG.5.224 SEASONAL AVERAGES OF pH FOR DUFFUS STREET, 1984-1985.

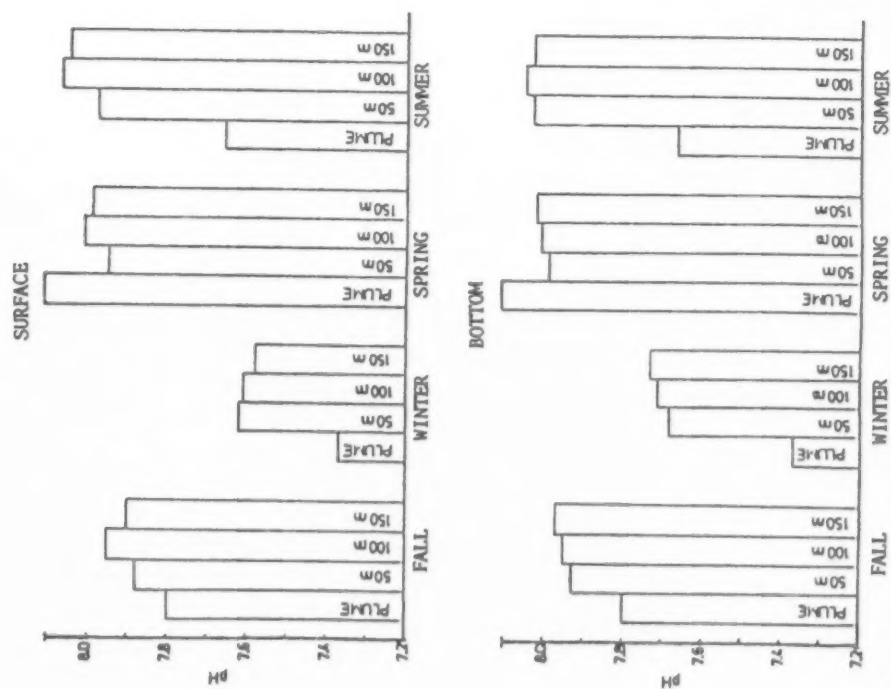


FIG.5.223 SEASONAL AVERAGES OF pH FOR TUFTS COVE, 1984-1985.

readings than Tufts Cove, and a clear adjustment pattern; thus low pH readings of winter and high spring values were present in Tufts Cove waters and was not evident for the Duffus Street outfall area. The pH variations between the surface and bottom waters were also very low and uniform, indicating a good horizontal and vertical distribution. The pH values of the reference sites were comparable to those of plume waters.

Dartmouth Cove

Seasonal averages of laboratory data are presented in Table D.3.4 of Appendix D.

The pH at the point of discharge was within ± 0.5 units of the other stations. There was a clear sign of vertical pH fluctuation in the water columns of every station. The pH variation between the stations was usual except for stations 8, 9 and 10. These stations had comparable pH values as those of the reference sites.

Sackville Street

Seasonal averages of pH data are presented in Table D.4.4 of Appendix D.

Considering the fact that the greatest pH change was ± 0.23 pH units no pH variation of these waters was evident. The reference stations also had similar pH readings.

Pier "A"

Seasonal laboratory data are presented in Table D.5.4 of Appendix D.

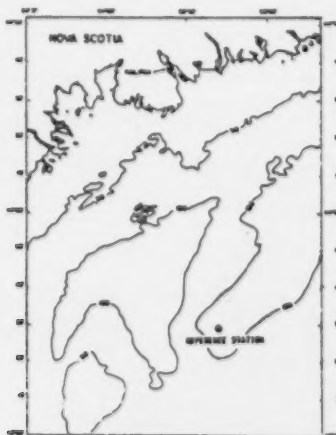
The pH readings at the point of discharge were approximately 1.0 unit less than the stations. The surface waters within the Pier had very similar readings to those of the bottom waters. This condition was altered when the plume of the overflow pipe was considered; the surface and bottom waters had pH values that varied nearly ± 0.8 units. The waters in the middle of the Harbour had slightly (± 0.5 units) higher pH readings than the plume waters.

Section 5.3 Analysis and Discussion of the Reference Data

In previous sections and subsections of this report those sites situated in the middle of the Harbour were named "Reference Sites", for referral convenience. As it was mentioned in subsection 3.6, the stations inside the Harbour were sampled to establish the size of the dispersion fields and the rate of contaminant transport through the Harbour into the Basin and out to the coastal waters. Whereas the actual reference site is located at a point approximately 150 km off the southern coast of Nova Scotia; and this site was monitored to estimate and compare the quantity of the 14 water quality parameters which were studied within the Harbour.

The quality of the Harbour waters are controlled by the input of sewage, industrial effluents, runoff and river discharges to this water body via a combined sewer system. Therefore, baseline data for this monitoring program was established by utilizing the results of a series of analyses on the seawater quality which did not directly receive any contaminants from these sources.

The field data received for the reference site were simulated values, serviced from the historical data of this site. The analysis of the biochemical activity of the reference site is moderately typical of this area. This site had a depth of 200 meters and was located in a major frontal area where its natural biological productivity depends on the state of the Gulf Stream. Current fluxes of Sable Island and the tidal activity of the Nova Scotia coast and Halifax Inlet specifically.



The seasonal values for the stations in the middle of the Harbour are presented in Tables R.1 to R.4 field data, R.5 to R.8 for Laboratory data, and Tables R.9 and R.10 of Appendix R contain data for the reference sites outside the Harbour.

5.3.1 Temperature

Temperature readings for stations inside the Harbour ranged from 8.0 to 9.5°C in fall, 0.4 to 2.3°C in winter, 1.5 to 4.0°C in spring and 3.0 to 10.0°C in summer. The comparable reference values were 5.0 to 8.5°C in fall, 0.6 to 16.6°C in winter, 5.0 to 7.5°C in spring and 4.8 to 17.5°C in summer.

Each section of the Harbour had its own distinct horizontal and vertical temperature distribution pattern. Station waters in the middle of the Harbour had irregular readings. The bottom stations had more uniform readings than those of the 5 meter and surface stations. The surface waters during winter had the characteristics of river water extending beyond Dartmouth Cove. The thermal characteristics of the stations on the Halifax side of the crossing line (stations 14-18), again were indicative of the movement of warmer waters through this area. The direction of this flow was seaward. Station 3 under the MacKay bridge also had higher temperature readings, indicating the flow of warm waters from the Basin to the Harbour which was also located on the Halifax side.

From the review of figures 5.3.1 to 5.3.4 which presents the data for the stations inside the Harbour, distinct distribution patterns of thermal changes were present in winter and summer. In winter, temperature readings were within a similar range and the bottom waters were cooler than the surface. The surface of the Harbour waters were warmer in every season, while the reference site outside the Harbour had warmer surface temperatures only in summer and fall. The presence of this condition was primarily due to the confinement of the Harbour and the presence and override of warm water discharges of sewage and river water. The latter was distinctly evident

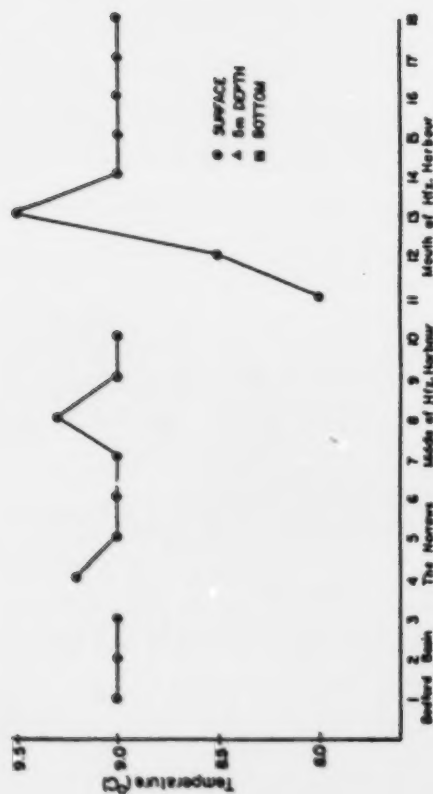


FIGURE 5.3.1 FALL SEASONAL AVERAGES OF TEMPERATURE FOR REFERENCE STATIONS, 1984.

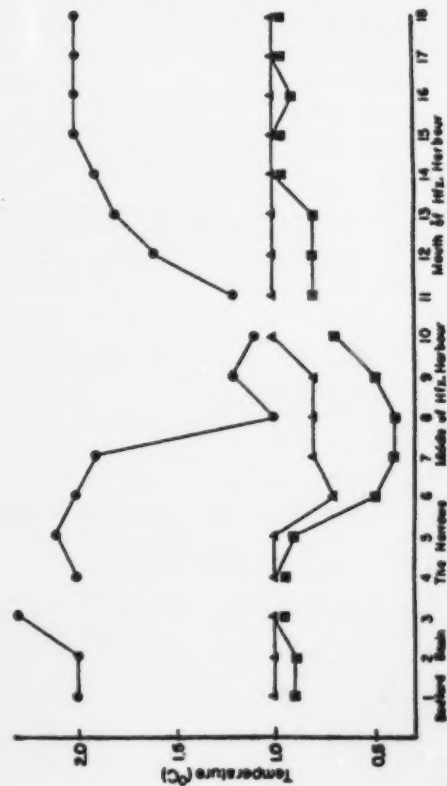


FIGURE 5.3.2 WINTER SEASONAL AVERAGES OF TEMPERATURE FOR REFERENCE STATIONS, 1985.

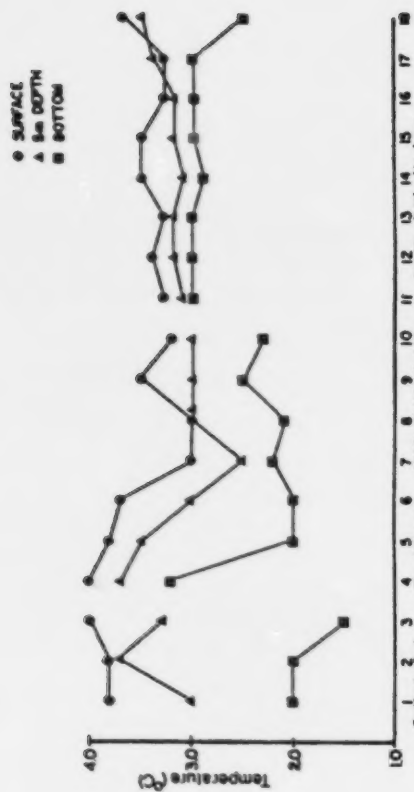


FIGURE 5.3.3 SPRING SEASONAL AVERAGES OF TEMPERATURE FOR REFERENCE STATIONS, 1985.

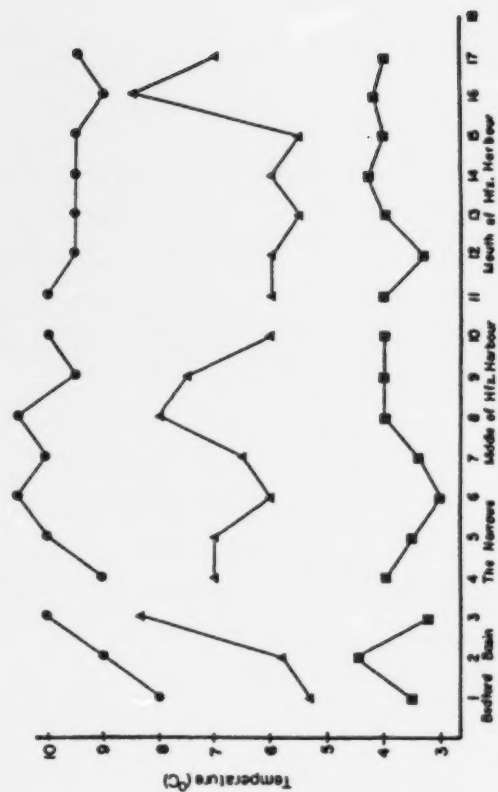


FIGURE 5.3.4 SUMMER SEASONAL AVERAGES OF TEMPERATURE FOR REFERENCE STATIONS, 1985.

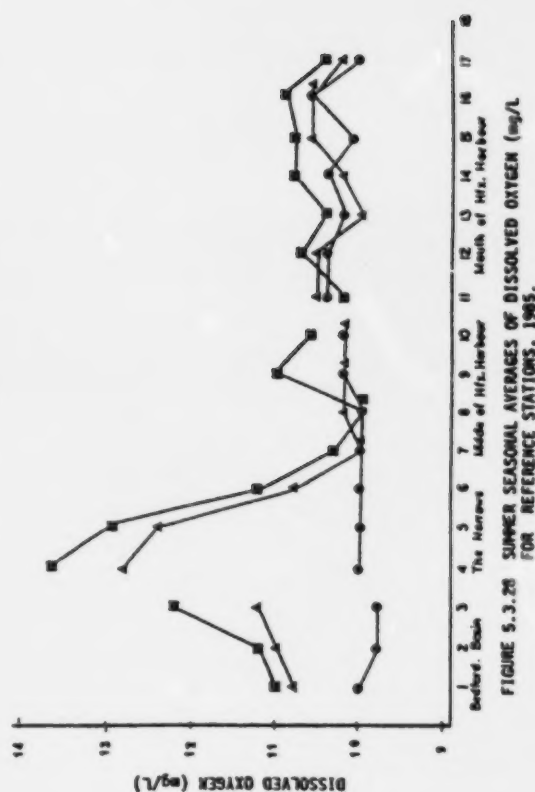
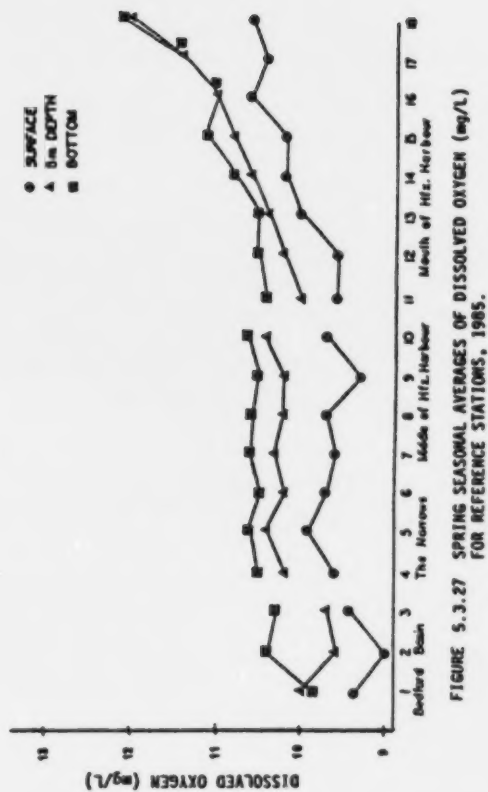
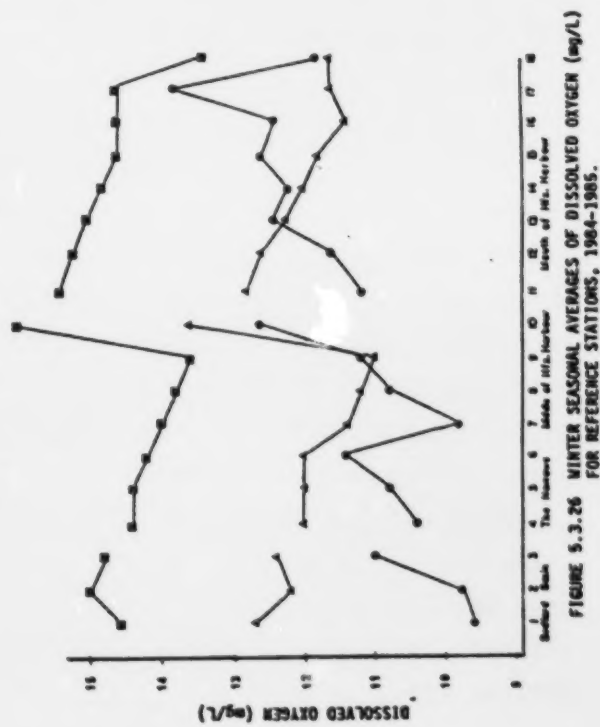
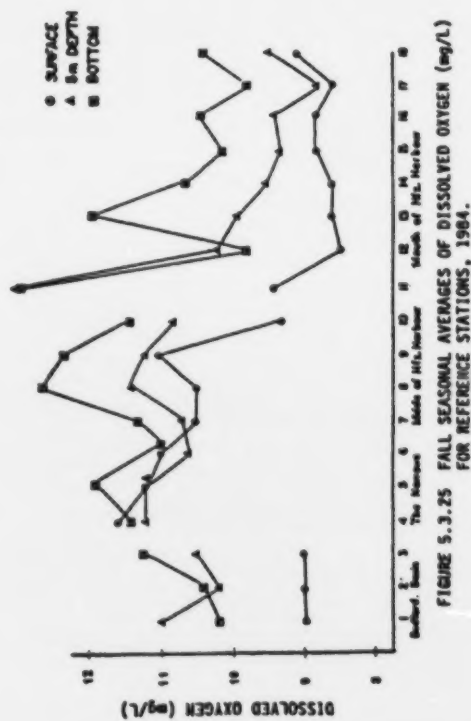
during winter 1984. Vertical thermal distribution also differed; the reference site outside the Harbour had a wider range of variation than those of the Harbour, because of the presence of deeper waters (up to 200 meters) within that area.

5.3.2 Dissolved Oxygen

Review of figures 5.3.25 to 5.3.28 shows dissolved oxygen concentrations of the stations in the Harbour ranging from 8.2 to 13.0 mg/L in fall, 9.2 to 16.0 mg/L in winter, 9.0 to 12.0 mg/L and 9.5 to 13.6 mg/L in summer. These values were lower than those of the reference station outside the Harbour reported by other studies. Only in the case of coastal water intrusions were these values comparable.

Dissolved oxygen content of the Bedford Basin was in the range of 4.8 to 7.8 mg/L for the surface, 5 and 10 meter depths (Kraul 1969). The depletion of the oxygen content of the Harbour was a function of elevated oxygen demand by the Bedford Basin waters as well as the demand of the sewage related contaminants. Sampling of the stations in the Harbour were not frequent enough to detect any drastic drop in oxygen content in the water columns. However, the near fields of the outfall sites and Bedford Basin had clear evidence of the existence of anoxic conditions in spring and especially in summer. From observations of the outfall sites the oxygen content of the waters intruding into the Harbour were not as high as initially expected.

In every season the dissolved oxygen content of the surface waters were substantially lower than the bottom waters (averages of ± 3.0 mg/L). For every season, the oxygen content of the water column at the entrance to the Basin were lower than that of the Harbour entrance except in summer when they were comparable. The oxygen content of the water columns showed a different distribution pattern for the upper 2 to 5 meters indicating a DO depletion of the superceding contaminated waters. The stations below the 5 meter depth had uniform and similar patterns of distribution as that of the bottom stations, with an exception for the stations under the MacKay Bridge which had more seasonal dependency. The greatest depletion rates and levels were present



from the stations before Tufts Cove to that adjacent to Pier "A" and this trend persisted from stations on the Dartmouth to Halifax side in the mouth of the Harbour, also.

A general depletion of dissolved oxygen existed from station 4 to station 10 in the middle of the Harbour indicating the demand of the wastes within this area. In the overall analysis of the data a sharp decrease in the oxygen content of stations 3 and 14 to 18 was a clear sign of a large wastewater movement on the Halifax side. This phenomenon could have resulted from the existence of a "waste stream", but further quantification of this hypothesis is needed.

5.3.3 Salinity

Review of figures 5.3.5 to 5.3.7 shows salinity values for the inner Harbour ranging from 10.0 to 30.6 in winter, 31.0 to 35.0 in spring and 27.5 to 31.0 g/kg in summer. The comparable reference ranges outside the Harbour were 32.6 to 34.5 in winter, 32.3 to 34.4 in spring and 32.8 to 34.3 g/kg in summer. These estuarine waters had an approximate level of 6.0 g/kg lower salinity than the reference site. The influx of freshwater was the major reason for the observed variability.

Each of the stations in the Harbour indicated a distinct salinity variability. During winter stations 1, 2 and 3 had lower salinity readings on the surface indicating the overriding of river water from the Basin. An intermediate layer of 1 meter had moderate salinity readings, whereas below the upper 2 meters the salinity reading reached the 29.0 g/kg range and was uniform indicating winter stagnation. The depth of low salinity override was more pronounced on the Halifax side, and the trend of low salinity surface waters prevailed in spring. The river water flows on the surface beyond Dartmouth Cove and the salinity recovers to the 29.0 g/kg range from there on. Relatively low saline waters passes through stations 14 to 18. Hence the salinity readings also support the flow of fresh and polluted waters on the Halifax side.

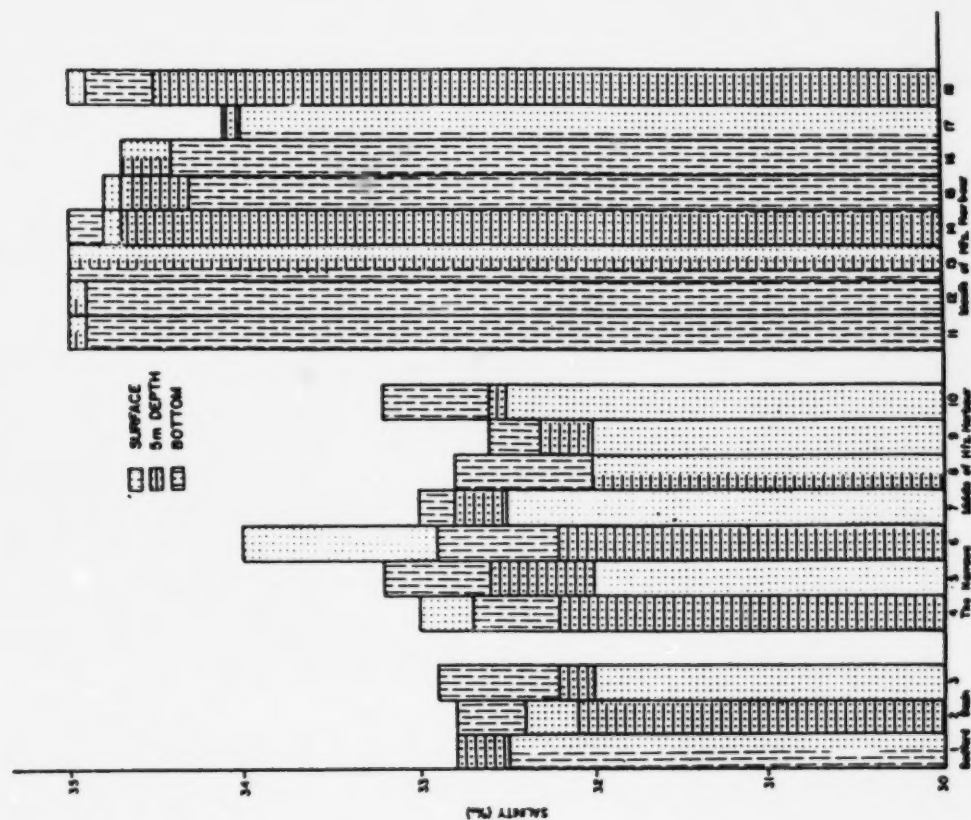


FIG.1.1.6 SEASONAL SALINITY FOR REFERENCE STATIONS FOR SPRING, 1985.

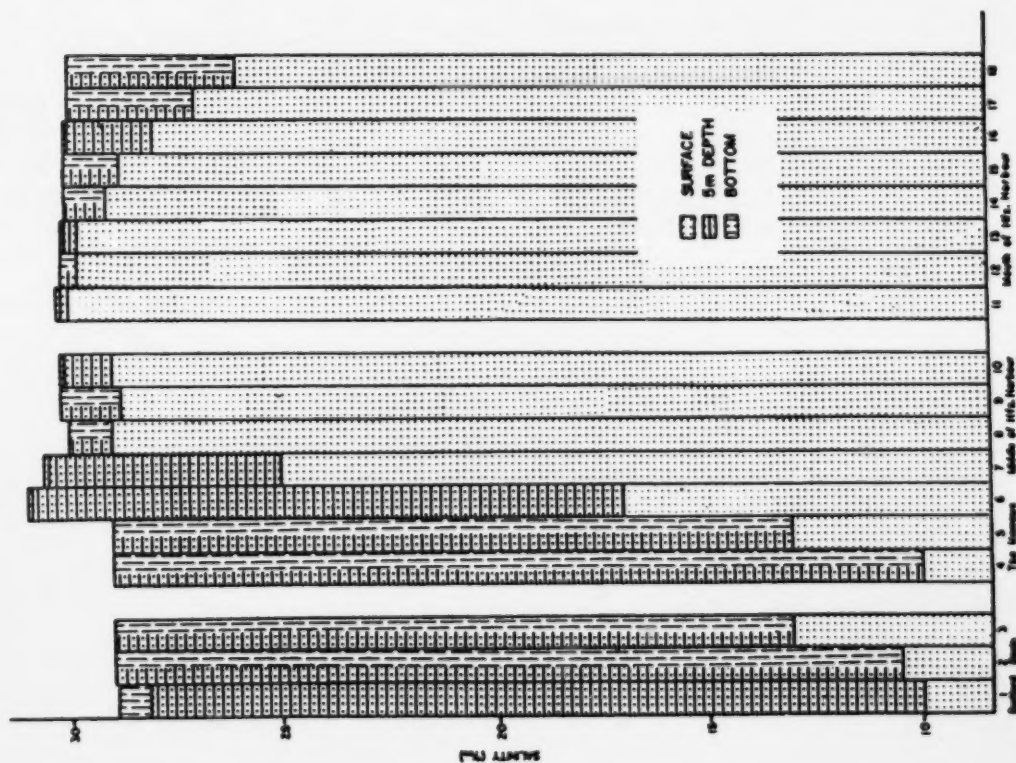


FIG.1.1.5 SEASONAL SALINITY FOR REFERENCE STATIONS FOR WINTER, 1985.

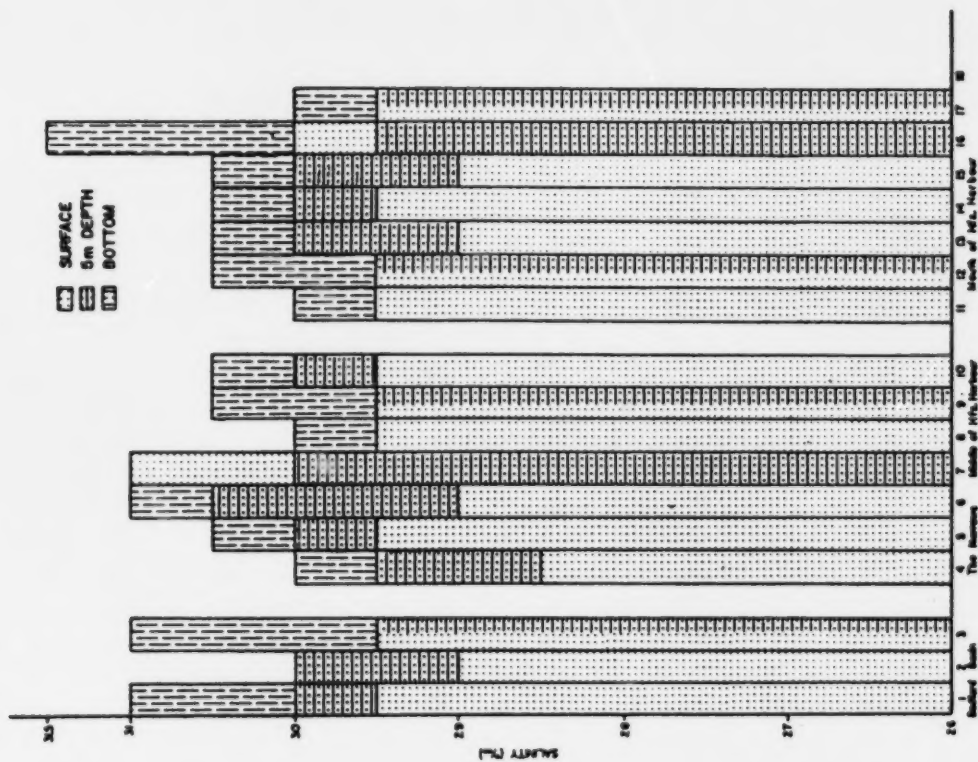


FIG. 3.1.7 SEASONAL SALINITY FOR REFERENCE STATIONS FOR SUMMER, 1985.

An overall recovery of salinity readings in spring was an indication of coastal water intrusion into the Harbour, as was observed in each outfall site. Vertical salinity distribution also supports the presence of intrusions since surface and bottom waters had readings that differed by ± 2.0 to 4.0 g/kg. The saline waters of the bottom (beyond 5 meter depth) had similar patterns of distribution throughout the year. Salinity of the Bedford Basin was 2.0 to 8.0 g/kg less than the coastal waters and 1.0 to 6.0 g/kg less than the Harbour waters. These lower salinity values at the entrance to the Basin in comparison to all the other sites was expected.

During summer the intermediate layers of the stratified water columns had greater salinity readings than the bottom and surface waters by 0.5 to 2.0 g/kg.

5.3.4 Conductivity

Review of figures 5.3.8 to 5.3.9 shows the conductance of the water column for both spring and summer to be in the range of $27,000$ to $29,500$ /cm. Thus, these values were not seasonally dependent. The seasonal values of conductivity correlated well with the salinity and temperature readings.

Horizontal distribution of the conductivity showed substantially lower readings at the mouth of the Basin and throughout the Harbour than those readings observed in the crossing line stations. This was more evident in spring when concentrations of soluble solids in the water columns of stations 1 to 10 were higher than stations 11 to 18. In spring uniform reading were evident through the water columns of each station. The intermediate layer of these waters apparently had relatively lower soluble solid content at the entrance to the Harbour and Basin than those in the middle of the Harbour.

During summer, the water columns had a distinct distribution pattern indicating the strong override of polluted waters on the surface, while the bottom waters were mostly effected by the activities of the bottom sediments. The intermediate, surface and bottom layers had their own specific highs and lows and indicated a very small correlation to one or the other. Constant water columns were apparent at the mouth of the Harbour.

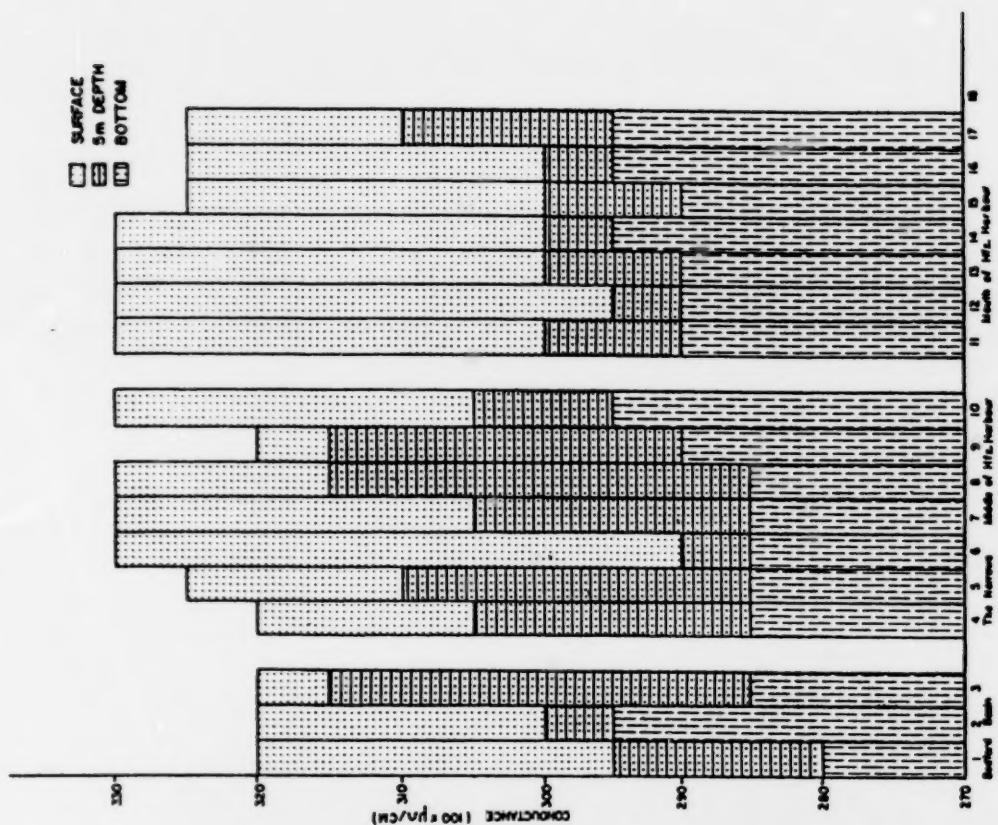


FIG. 1.1.9 SEASONAL CONDUCTANCE FOR REFERENCE STATIONS FOR SUMMER, 1985.

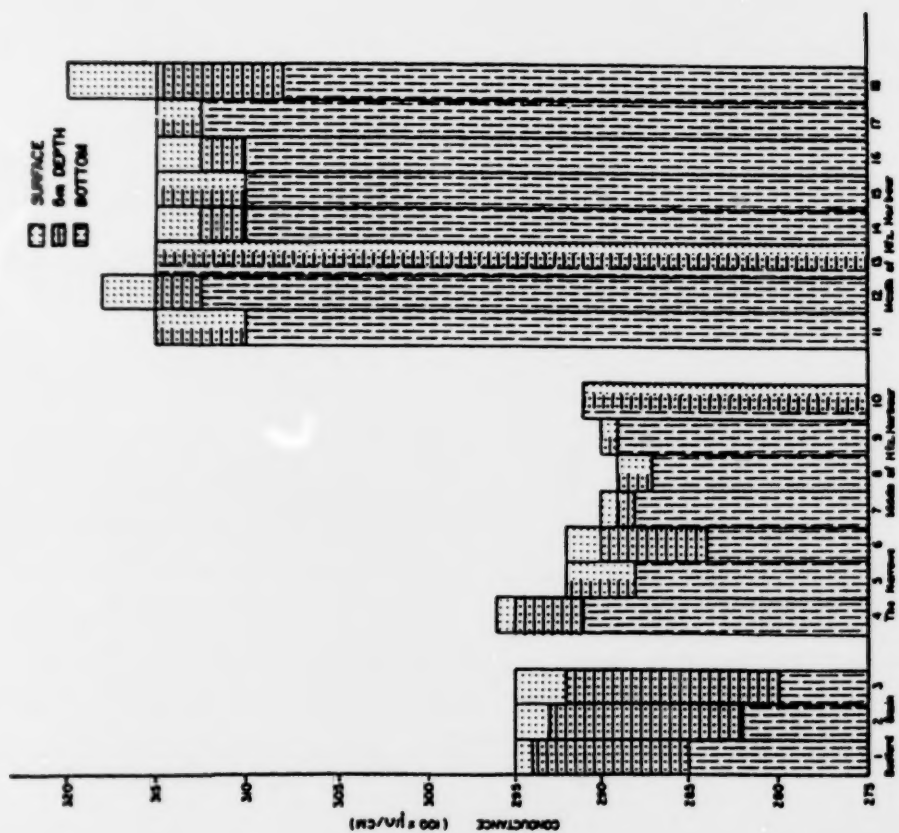


FIG. 1.1.8 SEASONAL CONDUCTANCE FOR REFERENCE STATIONS FOR SPRING, 1985.

5.3.5 Transparency

Review of figure 5.3.10 to shows transparency of the Harbour waters varying from 0.5 meters in winter to 4.0 meters in spring. However, these values were 1/2 to 1/5 of the values cited for natural sea waters of the Atlantic ocean.

The waters of the stations under the MacKay Bridge had lower transparency than the other stations; followed by transparency of those sites in the middle of the Harbour. There were low transparency readings at stations 16, 17 and 18 as well as 11 to 12. Low secchi disc readings, during winter, at the stations on the Halifax side supported the phenomenon where the contaminated waters flow seaward through this region. There was a recovery in transparency of the Harbour waters from the Basin to the crossing line.

5.3.6 Chemical Oxygen Demand

Review of figures 5.3.11 to 5.3.12 shows a very variable range of 13.5 to 441.6 mg/L of COD present in the stations of the inner Harbour during spring and summer of 1985.

The vertical distribution of COD readings in the water columns was very different, in so much as the behaviour of the surface waters were entirely independent of the bottom waters. These variations were less pronounced at the entrance to the Harbour indicating well mixed water columns. The superceding of the wastewater could be the reason.

General horizontal fluctuations were more evident in spring and uniformal in summer. The spring COD readings showed a great fluctuation of these values between each station.

A net transport of COD into or out of the Basin and seaward was evident.

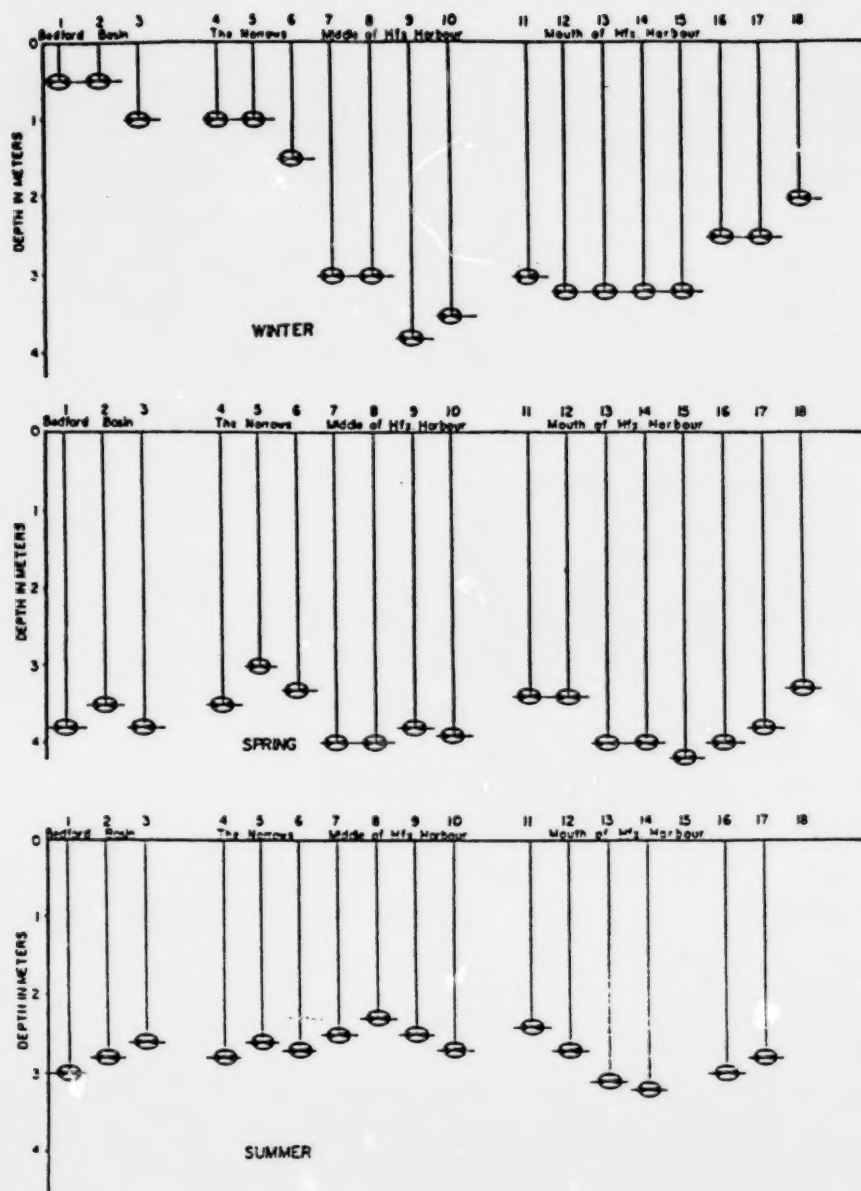


FIG. 5.3.10 SEASONAL SECCHI DISC READING FOR REFERENCE STATIONS, 1985.

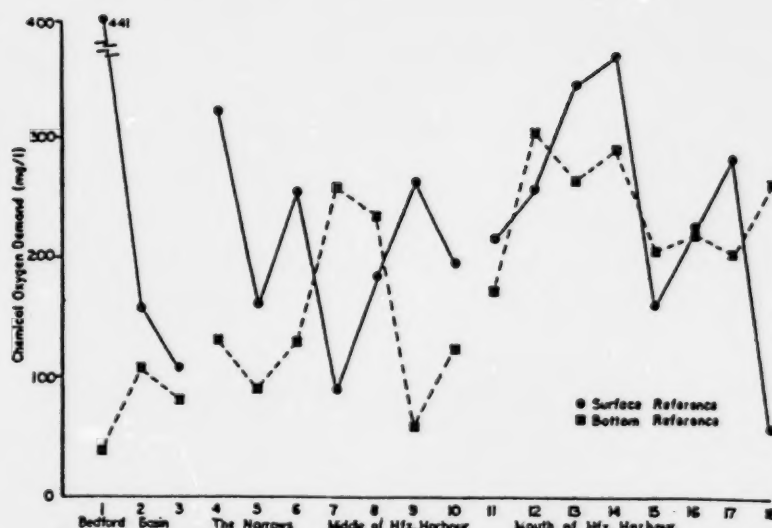


FIGURE 5.3.11 SPRING SEASONAL AVERAGES FOR CHEMICAL OXYGEN DEMAND FOR REFERENCE STATIONS, 1985.

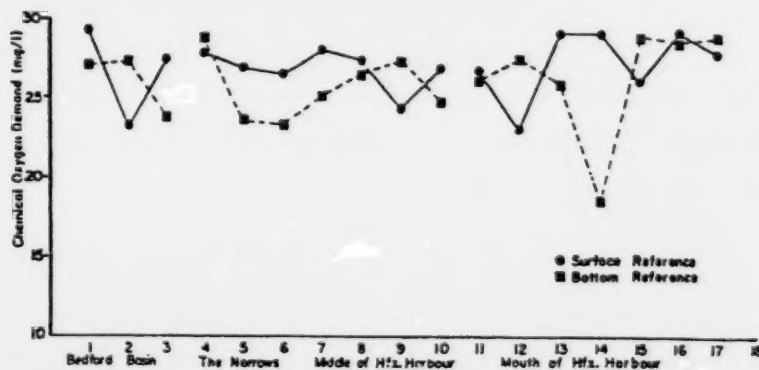


FIGURE 5.3.12 SUMMER SEASONAL AVERAGES FOR CHEMICAL OXYGEN DEMAND FOR REFERENCE STATIONS, 1985.

5.3.7 Biochemical Oxygen Demand

Review of figures 5.3.13 to 5.3.16 shows the biochemical oxygen demand content of the Harbour waters to be in the range of 3.4 to 2.4 mg/L in fall, 1.0 to 4.0 mg/L in winter, 1.0 to 2.2 mg/L in spring and 2.4 to 4.0 mg/L in summer. The respective values for the reference site were 3.3 mg/L in fall, 4.0 mg/L in winter, 1.7 mg/L in spring and 3.8 mg/L in summer. The BOD values of these two regions were in a similar range.

The vertical distribution of the BOD content in the water columns showed a greater concentration of contaminants in the surface waters. A similar pattern of behaviour was present between the surface and bottom waters during fall and spring while the other two seasons showed rather unrelated characteristics.

The horizontal distribution of the BOD readings indicated the presence of a high concentration of contaminants in the water columns under the MacKay Bridge followed by the Harbour (stations 4-10) and then the crossing line stations (11-18). On most occasions, there were higher BOD values on the Halifax side of the crossing line but this condition was reversed at the entrance to the Basin due to the transport of contaminants from Tufts Cove into the Basin on the Dartmouth side. A general increase in BOD and COD was evident around stations 5 to 8 which were located between Tufts Cove and Sackville Street. Thus the water columns of this region apparently received a larger content of the contaminants and the removal rate was sporadic for each season.

It was conclusive that the BOD content of the Harbour, beyond the near fields of the outfall sites, were similar to that of the reference site.

5.3.8 Suspended Solids

Review of figures 5.3.17 to 5.3.20 shows the suspended solid concentrations of the Harbour waters to be in the range of 19.0 to 44.0 mg/L

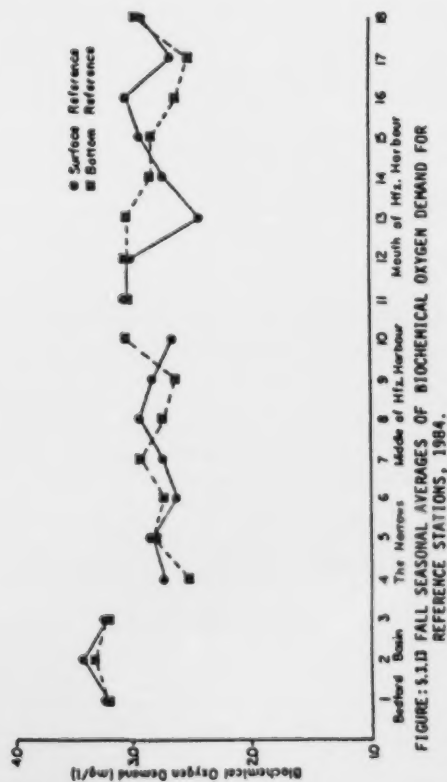
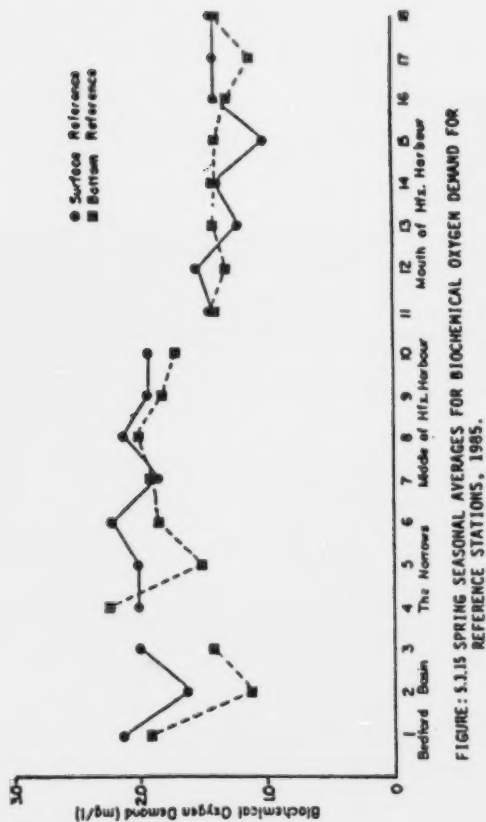


FIGURE: 5.3.1B SPRING SEASONAL AVERAGES FOR BIOCHEMICAL OXYGEN DEMAND FOR REFERENCE STATIONS, 1985.

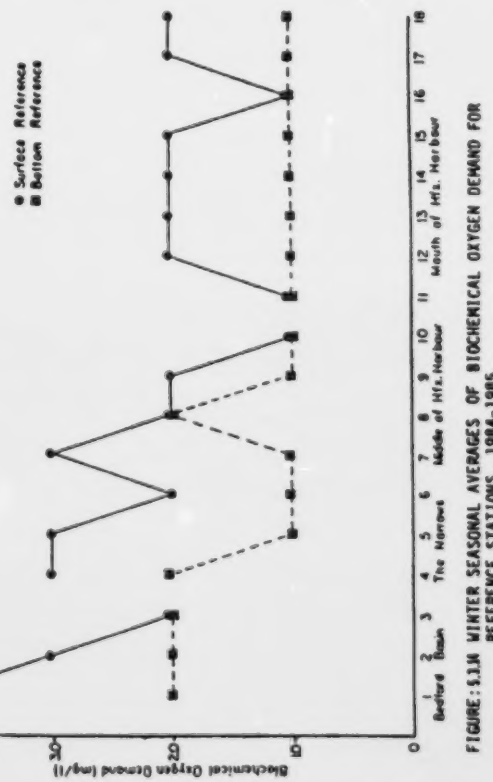
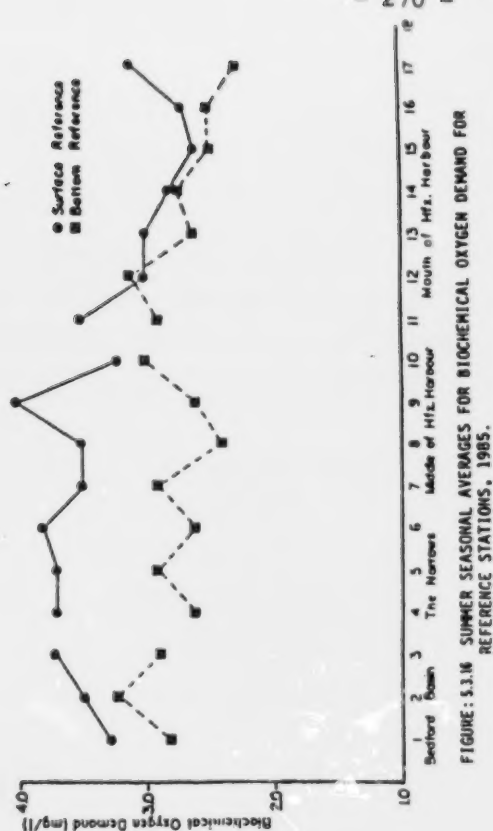


FIGURE: 5.3.1B SPRING SEASONAL AVERAGES FOR BIOCHEMICAL OXYGEN DEMAND FOR REFERENCE STATIONS, 1985.

FIGURE: 5.3.1B FALL SEASONAL AVERAGES OF BIOCHEMICAL OXYGEN DEMAND FOR REFERENCE STATIONS, 1984.

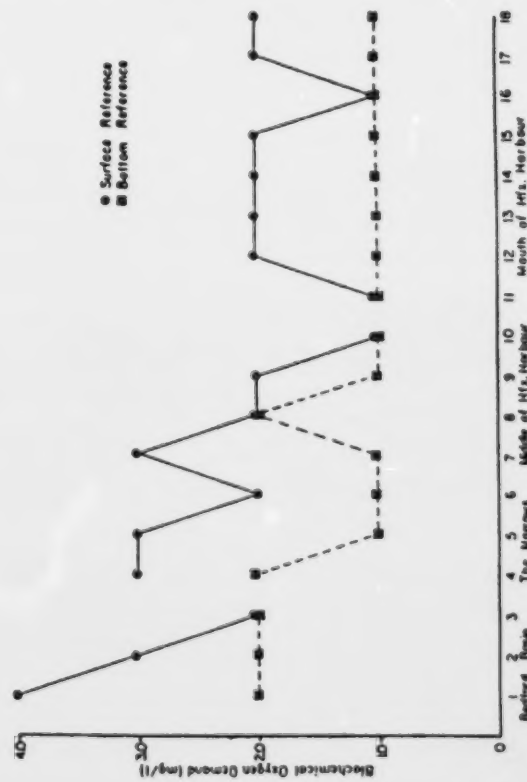


FIGURE: 5.3.1B WINTER SEASONAL AVERAGES OF BIOCHEMICAL OXYGEN DEMAND FOR REFERENCE STATIONS, 1984-1985.

in fall, 30.6 to 39.4 mg/L in winter, 19.6 to 35.8 mg/L in spring and 3.0 to 22.0 mg/L in summer. the corresponding values of the reference site were 40.0 mg/L in fall, 28.0 mg/L in winter, 32.0 mg/L in spring and 51.5 mg/L in summer. The plankton bloom of the reference site in spring and summer was the only time that the suspended solid concentration in these two bodies of water differed substantially.

The suspended solid content of the Harbour waters were similar in readings and vertical distribution pattern. Greater variations in the suspended matters of the water columns occurred in stations 2, 3, 5 and 11. The water columns at the entrance to the Basin showed a greater dependency to seasonal fluctuation indicating variable levels of transport patterns.

The horizontal distribution patterns of suspended solids were very uniform throughout the Harbour. There were no great fluctuations in the suspended solids concentrations between the regions within the Harbour. The greatest fluctuations from these uniform patterns of distribution were observed in stations 1, 3 and 5, 6, 9 and 10 of these three regions. The waste stream was not detected by analysis of this data set.

5.3.9 pH

Review of figures 5.3.21 to 5.3.24 show during each season a very narrow range of 7.5 to 8.3 pH values were observed. The upper limit of pH values were similar to the reference site. The vertical distribution showed a uniform pattern of pH readings between the surface and bottom waters except in summer; the readings were different but the distribution pattern was similar. The stations located under MacKay Bridge had more variable pH values in their water columns than the other sites, indicating more active surface waters since the bottom pH values were similar to the other stations.

The horizontal distribution pattern indicated lower pH readings in station 3 in every season. There was a drop in pH values in station 5, outside Tufts Cove, during spring; but the pH drop was only 0.4 of a pH unit which was insignificant.

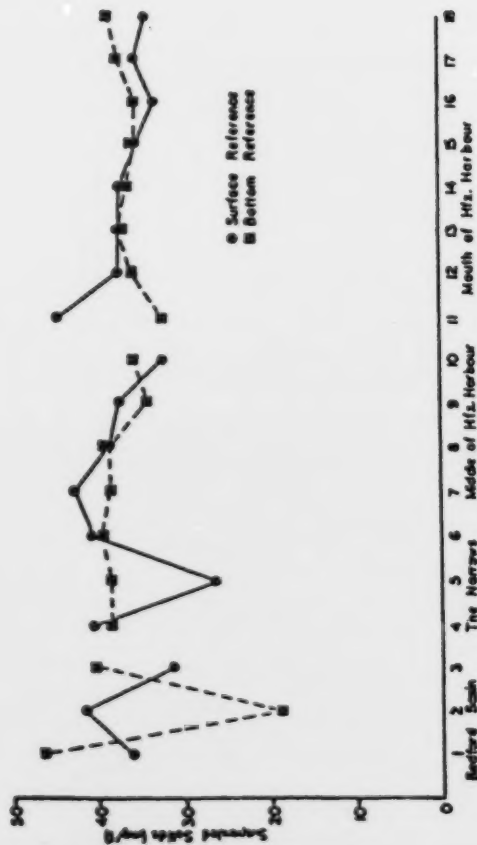


FIGURE: 5.1.7 FALL SEASONAL AVERAGES OF SUSPENDED SOLIDS FOR REFERENCE STATIONS, 1984.

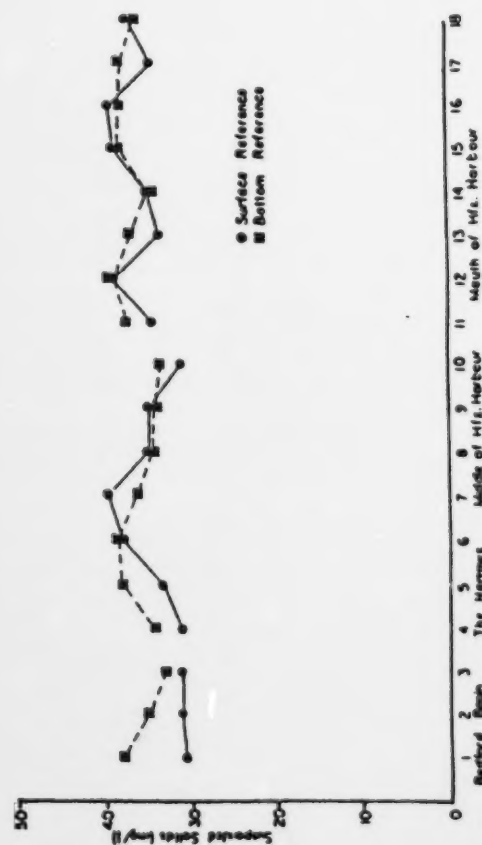


FIGURE: 5.1.8 WINTER SEASONAL AVERAGES OF SUSPENDED SOLIDS FOR REFERENCE STATIONS, 1984-1985.

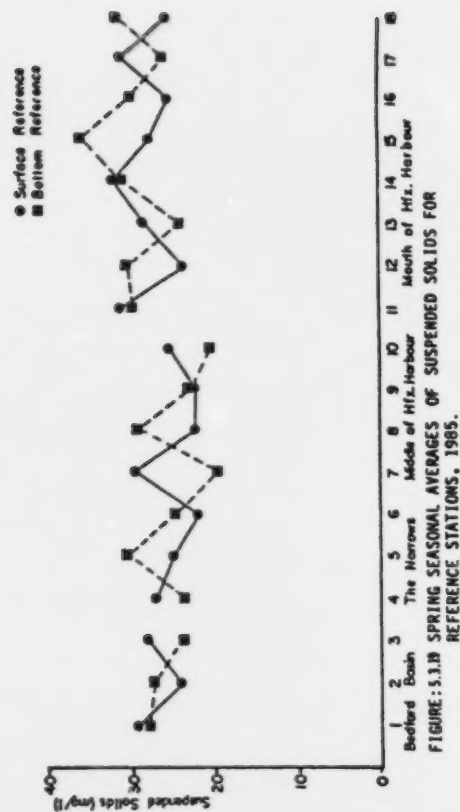


FIGURE: 5.1.9 SPRING SEASONAL AVERAGES OF SUSPENDED SOLIDS FOR REFERENCE STATIONS, 1985.

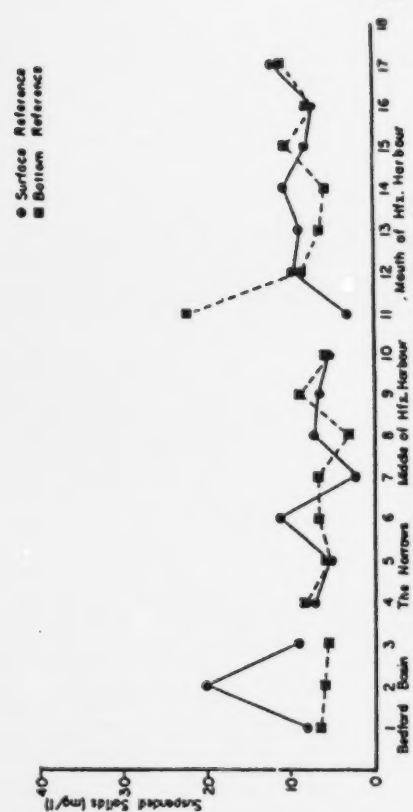


FIGURE: 5.1.10 SUMMER SEASONAL AVERAGES OF SUSPENDED SOLIDS FOR REFERENCE STATIONS, 1985.

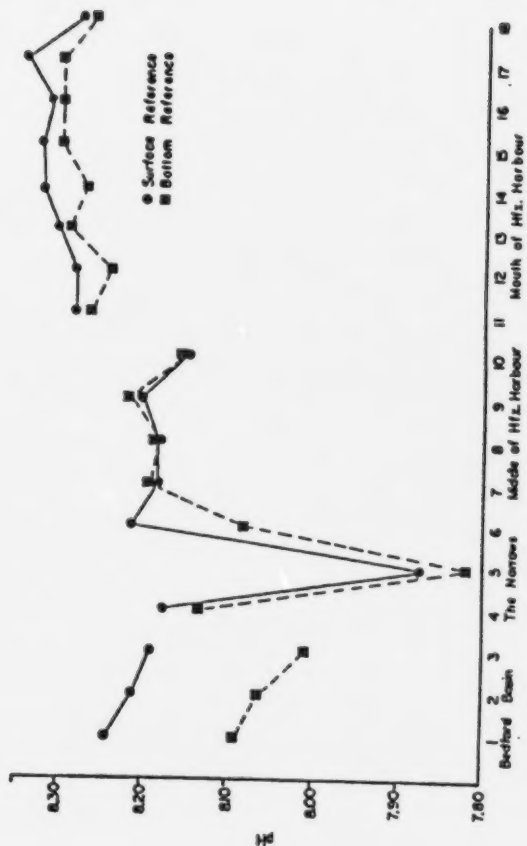


FIGURE 5.1.21 SPRING SEASONAL AVERAGES OF pH FOR REFERENCE STATIONS, 1985.

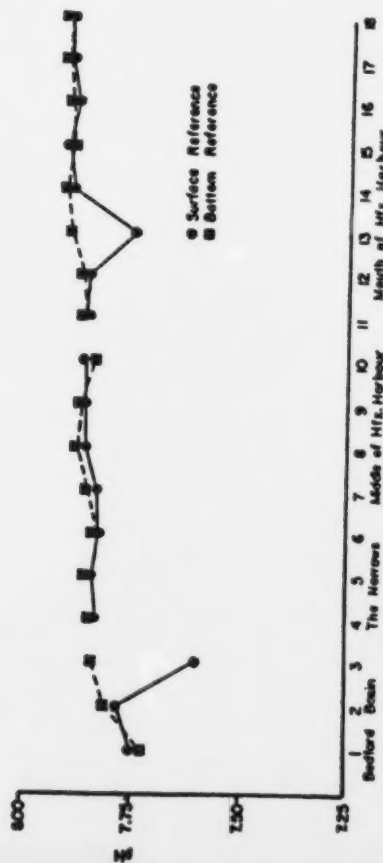


FIGURE 5.1.21 FALL SEASONAL AVERAGES OF pH FOR REFERENCE STATIONS, 1984.

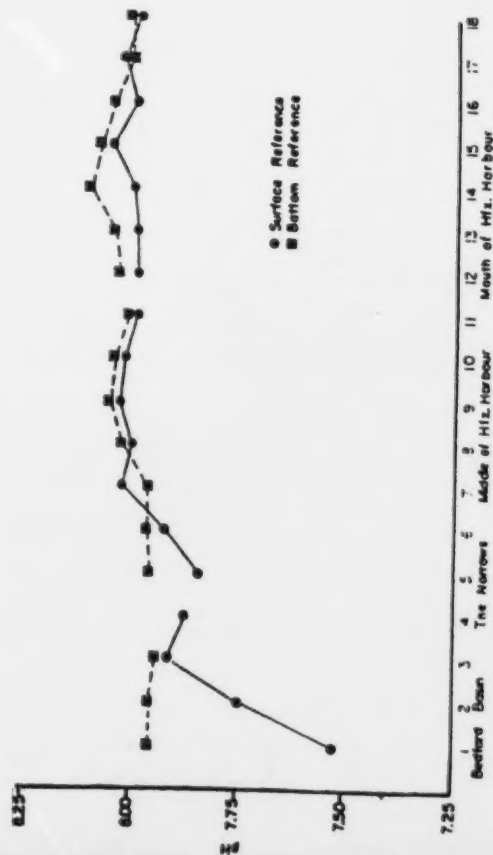
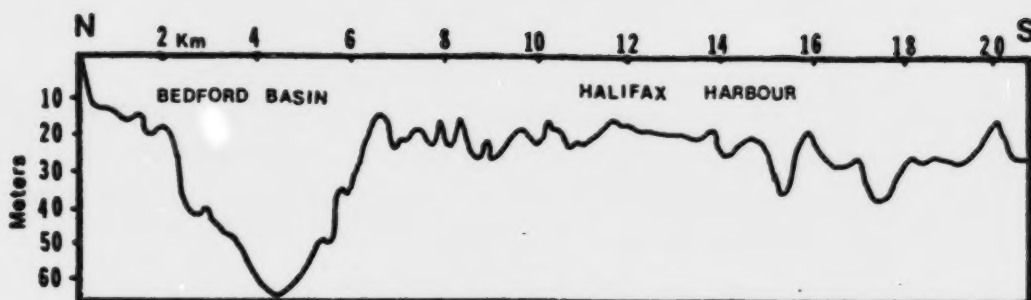


FIGURE 5.1.22 WINTER SEASONAL AVERAGES OF pH FOR REFERENCE STATIONS, 1984-1985.

Section 5.4 Effects of Turbulent Processes on Halifax Harbour Contaminant
Mixing, Dispersion and Removal

Estuaries, such as Halifax Harbour, are regions where mixing of fluids of variable densities occurs regularly; in which the processes of tides and currents are extremely important. These processes, have a significant impact on the diffusive nature as well as the circulation of the waters, in turn they decide, to a large extent, the fate of any contaminants that are present. Each one of the mixing mechanisms entail various processes, conditions and forces that decide the ultimate effects on the local waters. For instance, currents are a function of density gradients and wind, and are effected by the bathymetry of the waters under consideration. All these cause the flood or ebb water movement in an estuary located in the northern hemisphere. However, in every case without assessment of the physical and climatic conditions, the validity of the tidal and current conditions is questionable. Specifically, in the case of Halifax Harbour it is impossible to assess the containment or transport of the contaminants from the system without emphasizing the impact of the turbulent processes. The significance of the turbulent processes without a good measure of the level of pollution is also a problem.

In a great many estuaries, time dependent processes related to the tidal activities are obviously important. The level of importance is a function of physical and climatic conditions of the estuary. Halifax Inlet system is classified as a stratified fiord (fjord = connected with channel) type that is subjected to semi-diurnal tides (high and low tides are at 6 1/4 hour intervals). Halifax Harbour's physical configuration is of great significance in the behaviour of tidal and current mechanisms. A very large and deep Basin receives freshwater discharged from Sackville River and is connected through a very narrow and shallow Harbour to the coastal and shelfwaters. The climatic conditions such as wind velocity and direction, barometric pressure, air temperature, absolute humidity and precipitation also effect the water surface and cause sea level changes which enhance turbulence. At the same time variations in salinity, water temperature, freshwater intrusion and density of the ocean water controls the movement of the contaminants from Halifax Inlet.



The primary processes believed to be important in determining the fate of discharged contaminants into the Halifax Inlet system are: 1) tides, 2) mean current, 3) winds, both local and non-local 4) river discharges and 5) offshore forcing.

1. Tides

The tides of Halifax Harbour and along the entire Atlantic coast of Nova Scotia, are semi-diurnal. This type of tidal cycle has a high and a low tide every 6 to 6 1/4 hours, for a total of 2 tidal cycles per day. The tidal range above a datum is 1.4 meters in mean, 2.0 meters during a high tide and 0.6 meters at low tide. Total tidal amplitudes over a cycle are approximately 26 cm/sec (0.5 knots) (McGonigal et al 1974).

Water replacement by tidal currents is associated with the changes in sea level causing transport of contaminants by water, up and down the Harbour. In the absence of any other force the tides would simply act to move water back and forth with no net motion. In any other tidal cycle only a certain percentage of Inlet waters are being exchanged by the ebb and flood tides. So, if it was assumed that none of the water that has left the Inlet by an ebb tide was returned in the next flood tide, the net flushing rate of "Halifax Harbour" could be calculated with the Exponential Decay Rate formula:

$$V = V_0 e^{-at}$$

where: V = The volume of initial water remaining in the system after a tidal cycle.

V_0 = initial volume of the system.

a = length of the water column moved completely by a tidal cycle.

t = time of a cycle.

once: -at approaches 1

then: $V = V_0/e$ (e = folding time)

If the length of the Harbour is assumed as 15 km, the tide time equals 6 1/4 hrs, total amount of water transported from either side of the Harbour equals 2 km and the volume of water that has been removed is not being diluted and/or returned.

then $a = 1/15$ km per ebb or flood

and $t = 15$ km/2 cycles

Therefore -at approaches 1

From the above formula an approximate lower-bound flushing time for the Harbour by the tides was found to be 4 days. However, it is important to note that these flushing times are an estimate and they are a function of the amount of the water column that is actually being replaced during each tidal cycle.

Halifax Harbour primarily has predominantly tidal currents which tend to flow in the direction close to the axis of the Harbour. McGonigal and Loucks (1974) also observed the maximum amplitude of tidal current along the same axis. Based on these observations, maximum amplitude of tides along the axis of the Harbour were 26 cm/sec for 1/2 a tidal cycle and the velocity of water replacement by tides can be calculated from the average velocity of the tide over an ebb or flood as:

$$V_{avg} = 2V_{max}/\pi$$

Where: V_{avg} = average velocity of water movement

V_{max} = maximum velocity observed

Therefore: $V_{avg} = 16$ cm/sec (13.82 km/day)

This calculation translates to the movement of 3.6 km of Harbour water over a 1/2 of a tidal cycle and 7.2 km over 12 1/2 hrs. Therefore, the waters of the Narrows are being replaced over two tidal cycles that equates to one day.

However, it is of extreme significance to know that the basic assumptions are: (1) the Basin water is being replaced as it moves through the Narrows and no contaminants are transported back by the flood (2) the water transported outside the Harbour is not being brought back during the next tide cycle and (3) the strong winds do not enhance or hinder the tidal activity. Knowing these facts, it can be assumed that the waters of the Harbour are being diluted or replaced every 1 to 7 days and the waters of the Inlet system in 4 to 7 days by the forces of tidal activities.

2. The Mean Current

The Mean Current is the water movement associated with various physical processes. Halifax Harbour is subjected to two major conditions. The shape of the Harbour is such that rapid widening at Bedford Basin and MacNabs Island results in a "bottle neck" effect in the Narrows which restricts the intrusion of the deeper waters into the Basin. A continuous discharge and mixing of Sackville River waters lowers the salinity and density of Bedford Basin while dense and saline shelf water enters through the Narrows. These two conditions set a density gradient between the Basin, the Harbour and the coastal waters.

The water replacement resulting from the above mentioned and other mechanisms produces continuous net current within the Inlet system. This mechanism of water movement has low amplitude and impacts compared to the tidal and wind induced currents. On the average, Halifax Inlet's mean currents are one order of magnitude weaker than the tidal currents.

The upper 3 meters of surface water of the Inlet system flows seaward (McGonigal et al 1974) while from the 8 meter depth to the bottom layer moves toward the Basin. The seaward surface mean current is stronger on the Halifax side while the landward bottom current is weaker. At the same time, the thickness of the layers adjusts according to the balance of the volume of flow in both directions. In general, there are stronger bottom currents during the winter months. Overall mean currents of Halifax Harbour are also stronger during the late fall and winter.

The magnitude of the mean current is 2.5 cm/sec (0.03 to 0.075 knots). In the absence of any other mechanisms, mean current is capable of flushing the

Inlet system at a rate of 2.19 km/day, in a period of 5 to 11 days. These flushing times were calculated by H.H.P.M.P. from the current data provided by McGonigal et al 1974. The balance of inflow and outflow of the system indicates that by derivation of a net conservation equation which considers the precipitation and evaporation, the net outflow of 434 m³/year by mean current is not unusual.

3. The Winds

Winds are important in producing currents within coastal regions and the Halifax Harbour location. The effects are due both to local as well as non-local winds. The latter are those originated over the shelf. Setting up circulation patterns which effect water movement into and out of the Harbour.

Local Winds

Local winds blowing along the axis of the Harbour will tend to push surface waters in the direction of the wind, i.e. a northwesterly wind will tend to move surface water seaward while a southeasterly wind will push surface waters into the Bedford Basin. The magnitude of the surface velocities can be roughly estimated as 3% of the wind speed (Sandstrom, 1980). The depth of the layer effected by these winds depends upon the degree of stratification of Halifax Harbour. Strong stratification results in a shallow upper layer restricting the motion to this layer with the probability of opposing flow in the lower layer. In winter, when stratification is greatly reduced the direct wind-induced motions may extend to the bottom. At such times the currents induced by local winds will be expected to be greatly reduced in amplitude. During September 1984 to August 1985 the local winds (as reported for Shearwater) were predominantly northerly causing the piling up of surface waters into the Basin and the outflow of bottom Harbour waters.

Wind energy is significant for periods of 1 to 10 days duration with peak values concentrated at 3 to 7 days. During summer, due to the higher local winds over the Harbour and the strong stratification of the Inlet waters the effects of this mechanism are more pronounced. The high intensity, short

duration winter winds as well as weak stratification of the waters cause shorter periods of response while the summer winds and conditions produce a longer period of reaction of the waters to the local winds.

Non-Local Winds

Currents originating from the coastal and shelf areas are the result of two classes of wind induced turbulent action: a) extreme synaptical storms, b) other storms typical of the Nova Scotian region, especially Sable Island and coastal areas.

Tropical storms, as documented by Hachey, 1952, cause a great transport of shelf and coastal waters into the Harbour and replacing the Inlet waters. The centre of these storms need not be close to Halifax for a significant water replacement to occur. It has been assessed by Hachey and later by Longard and Banks, 1952, strong storms passing within 300 km of the coast of Nova Scotia can cause marked changes in water movement and replacement within the Inlet.

Under storm conditions, wind forces associated with the storm have to be in action for 12 hours for a piling action of the coastal and shelf waters or removal of the Harbour waters to happen. Longard and Banks 1952, explained the storm action as "...[for] vertical movement of the water a strong NE wind blowing for more than 1/2 day is shown to cause a landward movement of light surface waters and displace the bottom layers."

The current activities associated with the storms are synaptic; and they are a function of the wind forces, wind direction and storm duration. The amplitude of the wind related to these storms can only be measured and the magnitude of relevant water replacement and flushing time can be only estimated for each individual storm.

Storms typical to the Nova Scotia region

The water column in Halifax Inlet is vertically stratified during certain months of the year. The density is controlled by temperature and salinity variations resulting from several oceanographic and atmospheric processes.

Over the adjacent shelf the thickness of surface mixed layer varies from approximately 56 meters in January to 10 meters in July (Drinkwater and Taylor, 1982).

Currents forced by winds over the shelf, hereafter referred to as non-local winds, have a great impact upon the water replacement of Halifax Inlet. Due to effects of the earth's rotation, i.e. Coriolis force, winds blowing parallel to Scotian coastline, forces surface waters to the right looking downwind. Bottom waters at the same time are forced in the opposite direction to compensate the loss or build-up of surface waters at the coast. A mid layer is formed which is the "transient layer" between the two stratified surface and bottom waters which are moving in the opposite directions.

Along the Nova Scotian coast northeast winds force surface waters from the shelf towards the shore of Halifax Harbour, producing a rise in sea level. Bottom waters are forced by the across-shelf surface pressure gradient to move seaward; hence removing the bottom Harbour waters. During southwesterly winds surface waters move shoreward. The latter can result in cold subsurface waters entering the Harbour and removal of surface Harbour waters, as has been observed by Hachey 1935, Longard and Banks 1952, as well as Pettrie and Smith 1977.

Therefore in Halifax Inlet waters the non-isostatic response to the atmospheric pressure fluctuations is almost entirely a function of the response of the shelf waters to the pressure gradient and non-local winds (Heath 1973, Platt et al 1972). The predominant wind induced currents along the Nova Scotian shelf are those correlating to SW and NE winds. The water replacement activities act over a large horizontal scale all along the coast and into the bays and harbours of Nova Scotia. The immediate or delayed response to any storm is an isolated event and time dependent; thus a periodic turbulent process can not result from the non-local winds.

These low frequency, wind-induced currents are as influential in water replacement as tidal activities in Halifax Harbour. There are systematic responses of the sea level to the non-local wind stress of the offshore storm events with a duration of 2 to 14 days. The maximum impact of these events

are within the 4th day of the event (Heath 1973 and Sandstrom 1980). The sea level responds to a storm after approximately 12 hours; this lag time is more pronounced and higher in winter than summer, because of the strong stratification in the summer months which minimizes the impact of the frictional forces.

In April and July 1984 an apparent intrusion of shelf water was observed. The salinity of the bottom waters increased from an average of 29.0 g/kg to 35.0 g/kg. During March and June of the study period a strong Harbour water replacement also occurred when the average salinity changed from 29.0 g/kg to 33.0 g/kg. The Harbour water flushing was apparent during these times, but it has been documented that waters of the Nova Scotia coast are subjected to slow replacement that does not alter the salinity readings more than 0.5 g/kg. Hence, the slow flushing of the Harbour was in progress and it was not detected.

A seasonal comparison indicates that: the predominant winds during the summer are from a general southwesterly direction. Hence, in summer offshore movement of bottom waters are favoured. The reverse is true in the winter, when the predominating wind is from a northerly direction, favouring onshore movements of surface waters and offshore movements of bottom waters. These movements are being readily detected from the observations of salinity changes (Hachey 1937).

The net impact of the non-local winds on the Inlet is conclusively greater than the mean current and depending on the storm event stronger than tidal activities. There are significant impacts from these currents in moving the contaminants into the Basin and out of the Harbour. Sable Island winds represent winds that induce storm activity on the shelf effecting the Harbour.

4. River discharges

Compared to the volume of the Basin a relatively small amount of river water is being discharged into the Inlet. The magnitude of the impact from the discharge of $3.2 \times 10^8 \text{ m}^3/\text{yr}$ is 1.5 to 4.2 cm/sec.

Streams of hydrodynamic overriding freshwater are present within the Basin. In the winter of 1985 this condition was evident through the Basin, Narrows and past Dartmouth Cove, where the salinity returned to the seawater values.

5. Offshore Forces

Offshore oceanic influences on the Scotian Shelf and Halifax Harbour are directly related to: a) Nova Scotian current, b) slope waters, c) inshore Labrador current, d) Gulf Stream and e) the discharges of St. Lawrence River (Sutcliffe, 1975). Therefore, oceanographers conclude that these currents which effect the Gulf of Maine and Scotian Shelf also effect the Harbour waters.

Considering all the above mechanisms the questions remain regarding the final and net impact of these processes on the wastewater dilution and removal and also the flushing time for the Inlet system.

When the internal dynamic forces and the boundary conditions of an estuary specifies its character the ecosystem is autonomous. When the Halifax Inlet is not effected by outside forces, only the mean current and tides cause turbulence and certain physical, biological and chemical characteristics which result in internal changes in the water column; then this system is autonomous. The size of the Halifax Inlet system is the deciding factor for the average period of relative independence. It has been observed by Lewis and Platt, 1982 that the Halifax Inlet is autonomous for no longer than 2-3 days at a time during the spring phytoplankton bloom.

The governing conditions of the flushing time by any of the above turbulence mechanisms is a function of: characteristics and size of the contaminants, depth of the outfall pipe from the water surface, depth of pycnocline within the Harbour, velocity of the sewage at the point of discharge which decides on site horizontal and vertical mixing, physical configuration of the outfall which results in accessibility of plume waters to flushing activities, the seasonal behavioural changes of the contaminant resulted from climatic alterations and the size and physical features and characteristics of the Inlet system.

"It is concluded that except during the spring bloom, nutrient levels in the Inlet(s) on [the Nova Scotian coast] are controlled more by water movements on the Continental Shelf than by biological processes within the Inlet(s). Flushing of the Inlet(s) is more extensive in late summer and autumn. Water replacement occurs every year on this coast and flushing takes place on a broad front rather than effecting isolated Inlets." (Platt, Parkish and Irwin 1972). As it was mentioned in Nova Scotia the effective atmospheric fluctuations last about 4 days (Heath 1973). The sea level changes associated with these events indicate that the currents have the most energy in periods of 2 to 8 days, corresponding with the transient weather system. Sea level changes in the region correlate with along shore winds which cause piling of the surface waters in the Basin and removal of bottom waters (Sandstrom, 1980).

The analysis and calculations made by Lewis and Platt 1982 estimate an approximate flushing time of 5 days for Bedford Basin, assuming rapid and good mixing.

Summary

It is concluded by this study as well as others that the contaminants introduced to the Halifax Inlet are being directly flushed to the sea. Although certain levels of dilution or assimilation occurs within the system, the predominant mechanism is the pollutant removal by tidal and current activities. In general a duration of 1 to 10 days had been estimated for the total flushing of the Halifax Inlet system. Tidal current is the predominant mechanism of removal followed by the wind induced currents. The effect of mean current on overall flushing of the system is relatively small. Prediction of the impact of other mechanisms on water replacement is complex and beyond the scope of this study.

Section 5.5 Visual Indications of the Pollution within the Outfall Areas

Presently, only the area of Black Rock Beach (Point Pleasant Park) within the Harbour and parts of Bedford Basin and the Northwest Arm are still utilized for recreational purposes. These areas and the sites of Historic Properties, Fairview Cove Park and Dartmouth Park are the tourist attractions in the Halifax-Dartmouth area that are negatively effected by unpleasant aesthetic conditions.

During the monitoring period from September 1984 to August 1985, daily observations of visual conditions of the outfall areas were recorded. The results of these visual observations are illustrated in Tables 5.26 to 5.29 for each site. These tables contain in addition to aesthetic conditions of each outfall site the sampling time and its respective tide cycle, total precipitation for the sampling day and the day before, climatic conditions of the day for every sampling time.

Guidelines for effluent quality and wastewater treatment at federal establishments (EPS-1-EC-76-1, April 1976), state that discharges should be treated before being discharged to receiving waters so that they are free from floating debris, oil, scum and other materials in amounts sufficient to be noticeable in receiving waters.

The monitoring group compiled the following information on the aesthetic conditions in the immediate vicinity of the various outfalls and Harbour as a whole, based on visual observations taken from the shoreline and boat.

Tufts Cove

On all occasions the plume waters were highly turbid, which was more severe in the northern section. On occasions of apparent spills (Photoplates 10 and 11) or onshore sludge disposal, the turbidity was 100% throughout the cove. Discolouration due to the spills was generally observed to be black, purple and red (Photoplates 12 and 13); however, at other times discharges were gray and brown. On occasions of apparent spills, pH readings indicated large amounts of lime were being discharged.

Small size debris as well as; personal hygiene products and prophylactics were observed on the surface waters. Logs and solid garbage were in the vicinity of the cove on storm occasions.

Large surface slicks of oil and grease (e.g. home heating, gasoline, kerosene and diesel) were visible and extended beyond the Cove into the Basin. On all occasions, sewage scum was present, as well as grease balls, sludge balls and faeces. Odour associated with sewage and scum was very distinct during the sampling periods and more prominent during the summer months. Sludge in the Cove produced a substantial amount of gas bubbles which dislodged bottom sludge and refloated it.

The rocks on the shoreline were black and greasy. There was sewage fungus and brown seaweed present in the Cove and in the vicinity of the N.S.P.C. plant. Birds were present on the plume when no industrial discharges were visible (Table 5-25).

Duffus Street

A high level of turbidity existed in these waters (photoplate 6). Discolouration of the waters with (e.g. gray and brown). At certain times the temperature and density gradient was markedly differentiating the plume waters from the Harbour waters.

Debris of various sizes, personal hygiene products and prophylactics were observed on the shoreline and surface waters. During storms, logs and garbage were floating about. A visible surface slick, consisting of freshwater sewage, oils and greases, extended as far as the Halifax Industries.

Sludge balls were floating in the proximity of the discharge point, and gas bubbles were observed due to bottom sludge. Odour associated with these and the sewage was distinct at all times.

Sewage filamentous fungus was attached to the shoreline rocks and the Volvo Wharf in the vicinity of the outfall, along with brown marine weeds. In the vicinity of the wharf, rats were observed along with live and dead jellyfish. Birds were feeding on the sewage of the outfall (Table 5-26).

TABLE 5-25 GENERAL INFORMATION AND OBSERVATIONS
ON SAMPLING DAYS FOR TUFTS COVE, 1984-1985

DATE	TIME	TIME CYCLE*	TOTAL PRECIP. (mm) (DURING) (DAY BEFORE)	TEMP. °C	CLIMATIC CONDITION	VISUAL OBSERVATIONS (COLOUR, DEBRIS, GAS BUBBLES, OIL SLICKS etc.)
October 19	10:30	L 09:15	0.0	12.8	Sunny	
October 24	10:50	H 07:15	0.6	10.4	Cloudy	
October 31	09:45	L 07:55	18.6	8.3	Sunny	Dark green, debris, gas bubbles
November 15	12:45	L 06:50	0.0	2.6	Sunny	Debris
November 21	10:00	H 06:05	0.0	1.3	Cloudy, snowing	
November 28	10:15	L 06:20	0.0	3.1	Cloudy, foggy	Debris
December 5	11:25	H 05:35	0.0	-3.1	Cloudy, foggy	Tan, debris, gas bubbles
December 12	10:15	H 10:15	1.6	6.5	Cloudy, foggy	Tan, debris, gas bubbles
February 15	11:20	L 11:15	6.0	1.3	Cloudy, mild	
February 27	10:00	L 7:15	1.0	1.1	Foggy, mild	(Layer of scum and grease 50 m from plume)
March 11	10:00	L 5:35	0.0	0.1	Sunny, mild	Whitish, grease
March 15	10:00	L 9:50	0.0	1.6	Sunny, mild	(sludge bank visible)
March 27	10:30	L 5:40	0.0	0.5		(plume was very dirty along the shore)
April 9	10:00	L 5:15	1.2	-0.1	foggy, cloudy, brown debris, oil coming from plume	
April 12	10:00	L 8:25	1.2	0.5	Sunny, windy, purple, heavy debris (debris flowing towards mid harbour)	
April 24	09:45	L 4:30	0.0	4.6	Cloudy, windy, purple, light oil	
May 1	13:00	L 11:00	0.0	11.4	Sunny, mild	Much debris, gas bubbles
May 9	11:00	L 5:55	0.0	5.3		Blue, debris, gas bubbles
May 30	09:55	L 10:35	0.0	13.9		Blue, debris, gas bubbles
June 5	10:00	H 9:40	4.0	14.3	Sunny, mild	Reddish scum floating, gas bubbles, jellyfish
June 12	09:48	L 9:45	10.0	14.2	Cloudy	Large debris
June 27	10:00	L 9:10	16.2	11.1	Raining	Dark, gas bubbles, oil slicks
July 18	10:30	H 8:25	2.6	17.2	Raining	Gas Bubbles
August 2	09:00	H 9:05	0.0	16.2	Cloudy	Floating debris, light oil
August 9	09:30	L 7:55	4.3	19.6	Sunny, warm	Oil slicks
August 21	10:00	L 5:35	0.0	18.6		Sludge floating, gas bubbles (strong odour) (very dirty) gasoline smell

* L=Low, H=High

TABLE 5-26 GENERAL INFORMATION AND OBSERVATIONS
ON SAMPLING DAYS FOR DUFFUS STREET, 1984-1985

DATE	TIME	TIME CYCLE*	TOTAL PRECIP. (mm) (DURING) (DAY BEFORE)	TEMP. °C	CLIMATIC CONDITION	VISUAL OBSERVATIONS (COLOUR, DEBRIS, GAS BUBBLES, OIL SLICKS etc.)
October 10	10:20	H 08:10 L 14:20	0.0	6.7	Sunny	Turt, debris, sea gulls
October 17	10:00	L 06:50 H 12:20	0.0	7.9	Cloudy, windy	
October 26	10:00	H 08:50 L 15:30	0.0	4.7	Cloudy, windy	
November 2	10:00	L 09:45 H 15:30	6.4	9.1	Cloudy, few seagulls	
November 9	09:45	H 08:05 L 14:30	0.0	0.4	Sunny	debris, gas bubbles
November 16	10:00	L 07:50 H 13:05	1.2	9.2	Cloudy, windy	Tan, debris, gas bubbles
November 23	10:30	H 07:40 L 14:35	0.0	3.5	Cloudy, windy	Tan and green debris, seagulls
November 30	10:30	L 08:20 H 13:30	0.6	7.0	Cloudy	Tan and green
December 7	10:16	H 06:50 L 13:35	1.8	1.1	Cloudy, windy	Lebris, gas bubbles
December 14	10:00	L 06:35 H 11:50	0.0	-0.9	Sunny, windy	Tan
February 20	11:30	H 08:25 L 15:00	0.6	-2.0	Sunny, mild	
March 1	10:00	L 09:15 H 15:05	0.0	-3.5	Sunny	
March 13	10:00	L 07:45 H 13:00	19.4	3.0	Cloudy, mild	(colour gradient, 100 meters from the plume)
March 22	12:00	H 08:45 L 14:55	0.0	-3.9	Sunny, windy	
April 10	10:00	L 06:20 H 11:50	0.0	-0.3	Sunny, brown debris	
April 18	10:00	H 07:00 L 13:20	0.0	1.9	Sunny, windy	(distinct colour gradient moving to mid harbour)
April 30	10:00	H 03:15 L 10:05	0.0	9.2	Sunny, mild, grey	
May 9	10:00	L 05:55 H 11:40	0.0	5.3	Blue, (warm water discharging from the plume)	
May 16	09:45	H 05:50 L 12:00	1.6	8.7	Sunny, scum, grease	
May 22	10:00	H 09:45 L 15:40	13.8	10.7	Cloudy, heavy flow, jellyfish	
June 14	10:00	H 05:15 L 11:10	.4	12.4	Cloudy, debris, few jellyfish	
July 3	09:30	H 08:35 L 15:00	0.0	16.0	Cloudy, rain, debris, few jellyfish	
July 10	09:50	L 08:00 H 14:00	0.0	16.7	Cloudy, debris, garage oil	
					Rats nearby and dead starfish.	
July 26	10:00	L 08:55 H 14:40	13.0	18.7	Dead jellyfish	
					Cloudy, grey	
August 14	10:00	H 06:30 L 12:30	0.0	16.9	Calm, grey	
August 22	10:00	L 06:40 H 12:15	0.0	17.9	Cloudy	

* L-Low, H-High

Dartmouth Cove

The Maitland Street outfall showed high levels of turbidity, while the Old Ferry Road outfall showed less turbid waters, although the plume covered the entire cove. The discolouration of the plume was predominantly gray and on occasion brown. Temperature and density gradients were observed between the plume waters and extended to the Harbour waters. The turbidity was concentrated in the vicinity of the shipwrecks (Station 6).

Few floatables such as personal hygiene products, prophylactics and faeces were observed in the waters and on the shoreline. After storms larger debris was also present. Large surface slicks, consisting of oil and sewage were visible on occasions, which extended out of the cove and towards mid-Harbour.

Grease and sludge balls were observed in the warmer months. Odours associated with the sewage of the outfall and sludge banks were evident during our sampling periods. Sludge in the vicinity of the shipwrecks appeared to be producing a substantial amount of gas bubbles, possibly due to the stagnation and containment of the Cove.

The shoreline rocks, wharves and shipwrecks showed an abundance of sewage fungus attached to them (Table 5-27).

Sackville Street

The plume area was severely turbid within 150 meters of the plume area, indicating a drift of the sewage seaward. Discolouration of the waters was gray and brown (photoplate 7).

There was a continuous presence of small debris and faeces in the water column. Floatables such as personal hygiene products and prophylactics were observed, regularly.

Surface slicks of oil, grease and scum associated with freshwater sewage was observed on occasion. Sludge balls were present on occasion. Gas bubbles associated with sludge were also observed, and odour associated with sanitary sewage and oil was distinct and more evident in the summer months.

TABLE 5-27 GENERAL INFORMATION AND OBSERVATIONS
ON SAMPLING DAYS FOR TARTHOOTH COVE, 1984-1985

DATE	TIME	TIME CYCLE*	TOTAL PRECIP. (mm) (DURING) (DAY BEFORE)	TEMP. °C	CLIMATIC CONDITION	VISUAL OBSERVATIONS (COLOUR, DEBRIS, GAS BUBBLES, OIL SLICKS etc.)
October 10	10:40	H 08:10 L 14:20	0.0	6.7	Sunny	Debris
October 18	10:15	L 08:00 H 13:25	0.0	8.5	Cloudy	
October 25	09:55	H 08:00 L 14:55	0.6	10.0	Sunny, calm	
November 1	09:45	L 08:55 H 14:15	0.0	5.0	Sunny	Brown debris, birds, dead fish
November 22	09:45	H 06:55 L 13:45	0.0	3.1	Sunny	Tan
November 29	10:15	L 07:15 H 12:30	2.2	6.4	Cloudy	Tan, debris, birds, sea gulls at the plume
December 6	09:45	H 06:20 L 12:45	23.1	2.2	Cloudy	Debris
December 13	09:50	H 11:05 L 18:05	0.2	7.5	Cloudy	Debris, oil slick, sea gulls at the plume
February 22	09:45	H 09:45 L 16:00	4.8	-4.3	Sunny	
February 28	09:52	L 08:15 H 13:55	2.0	-4.5	Sunny, partly cloudy	
March 6	10:30	H 07:10 L 13:45	0.0	-12.9		
March 20	09:54	H 07:25 L 13:55	0.0	-2.6	Sunny	Debris, sea gulls at the plume
March 29	13:00	L 07:45 H 13:10	0.2	6.7	Sunny	Sea gulls at the plume
April 4	10:00	H 06:50 L 13:15	8.4	1.1	Cloudy	Many sea gulls at the plume
April 17	10:30	H 06:20 L 12:45	0.2	2.9	Sunny, few clouds	Sea gulls at the plume
April 26	08:00	L 06:10 H 12:00	0.0	7.2	Sunny	Grey, debris, sea gulls at the plume
May 10	10:00	L 07:00 H 12:35	0.0	-0.3	Sunny	Sea gulls at the plume
May 24	10:00	L 05:00 H 11:00	0.0	14.1	Sunny	Brown, sea gulls at the plume
May 31	10:00	H 05:05 L 11:50	0.0	11.0	Sunny	
June 20	11:45	H 09:25 L 15:25	0.0	15.7	Sunny	Grey, sea gulls at the plume
June 28	10:00	H 03:40 L 10:10	11.4	13.5	Foggy	Grey, debris, gas bubbles
July 5	10:00	L 04:15 H 10:15	0.0	21.3	Sunny	
July 19	10:00	H 09:05 L 15:05	0.0	18.4	Sunny	Sea gulls at the plume
August 8	10:30	L 07:05 H 13:00	10.8	18.3	Sunny	Grey, sea gull at the plume
August 16	10:00	H 08:00 L 14:00	6.6	20.6	Foggy	

* L=Low, H=High

TABLE 5-28 GENERAL INFORMATION AND OBSERVATIONS
ON SAMPLING DAYS FOR SACKVILLE STREET, 1985

DATE	TIME	TIDE CYCLE*	TOTAL PRECIP. (mm) (DURING)(DAY BEFORE)	TEMP. °C	CLIMATIC CONDITION	VISUAL OBSERVATIONS (COLOUR, DEBRIS, GAS BUBBLES, OILSLICKS etc.)
February 14	11:00	L 10:10 H 16:00	2.2	2.0		
February 21	10:00	H 09:05 L 15:30	0.0	-8.3	Sunny, cold	Odour present
March 18	10:00	H 06:00 L 12:40	2.0	-3.8	Light snow	Odour present
March 25	10:35	H 10:30 L 16:15	0.0	-3.6	Cloudy	Odour present
March 28	10:00	L 06:40 H 12:20	0.2	2.3	Cloudy	Odour present
April 11	10:15	L 07:25 H 12:55	0.0	1.3	Cloudy, high winds	Odour present
April 19	10:00	H 07:40 L 13:50	0.0	6.6	Sunny	Odour present
April 25	09:40	L 05:15 H 11:15	0.0	7.9	Sunny	Odour present
May 17	09:35	H 06:30 L 12:40	3.0	11.6	Cloudy	Odour present
May 23	09:40	L 04:15 H 10:20	0.0	13.4	Sunny	Odour present
May 29	09:50	L 09:35 H 15:50	0.0	12.2	Cloudy	Odour present
June 13	09:40	H 04:20 L 10:30	1.2	8.3	Cloudy	Odour present
June 21	10:00	L 03:55 H 16:10	0.0	17.7	Sunny	Odour present
June 26	10:00	L 08:10 H 14:10	20.4	11.3	Rain	Odour present
July 4	10:00	H 09:25 L 15:50	0.0	17.9		Discolouration Odour present
July 11	10:00	L 08:50 H 14:50	3.3	16.6	Rain	Grey Odour present
August 7	10:30	L 06:25 H 12:15	0.0	20.9	Sunny	Grey Odour present
August 15	09:30	H 07:15 L 13:15	0.0	22.2	Sunny	Grey Odour present

* L-Low, H-High

There was abundant sewage fungus present on the wharves and boats in the vicinity of the outfall (Photoplate 7). The Halifax residents and tourists are faced with the unpleasant aesthetic conditions of the Sackville Street outfall (Table 5-28).

Pier "A"

There was always a high level of turbidity present as far as 600 meters from the point of discharge (photoplate 1 and 2). The City of Halifax, discarded the refuse of snow removal into the Pier, which increased the amount of suspended matter within the water column. The discolouration of the waters was gray, brown and on a few occasions red.

Regularly, floatables such as personal hygiene products, prophylactics, faeces and dead birds (pigeons) were observed on the surface waters. Surface slicks of oil, grease and freshwater sewage scum were present on occasion, which extended seaward in a large plume. Frequently when the grain loader was operating adjacent to the Pier, large amounts of grain dust were floating on the surface waters.

The sludge layer of Pier "A" produces a large amount of gas bubbles, especially in the summer months, which leaves the entire area very odourous.

There is abundant sewage fungus attached to the Pier walls (refer to photoplate 2) and the boats docked within the Pier had sewage fungus attached to their hulls.

The outfall is located in the intertidal zone on a high energy shoreline on occasions of high winds, the waves breaking on the Pier walls adjacent to the outfall produce an aerosol drift which is contaminated by sewage (Table 5-29).

Reference Sites

During the four seasons of sampling and visual observations, a number of observations were made at the eighteen sites in the Harbour. The observations may be summarized as:

TABLE 5-29 GENERAL INFORMATION AND OBSERVATIONS
ON SAMPLING DAYS FOR PIER A, 1985

DATE	TIME	TIDE CYCLE*	TOTAL PRECIP. (mm) (DURING) (DAY BEFORE)	TEMP. °C	CLIMATIC CONDITION	VISUAL OBSERVATIONS (COLOUR, DEBRIS, GAS BUBBLES, OILSLICKS etc.)
February 14	11:30	L 10:10 H 16:00	2.2	2.0	Sunny, cold	
February 21	10:45	H 09:05 L 15:30	0.0	-8.3		
March 18	10:45	H 06:00 L 12:40	2.0	-3.8	Light snow	
March 25	11:00	H 10:30 L 16:15	0.0	-3.6	Cloudy	Few birds
March 28	10:45	L 06:40 H 12:20	0.2	2.3	Cloudy	Sludge
April 11	10:50	L 07:25 H 12:55	0.0	1.3	Cloudy, high winds	
April 19	10:45	H 07:40 L 13:50	0.0	6.6	Sunny	Grey
April 25	10:15	L 05:15 H 11:15	0.0	7.9	Sunny	Grey
May 17	10:15	H 06:30 L 12:40	3.0	11.6	Cloudy	Grey
May 23	10:15	L 04:15 H 10:20	0.0	13.4	Sunny	Grey
May 29	10:30	L 09:35 H 15:50	0.0	12.2	Cloudy	Grey
June 13	10:15	H 04:20 L 10:30	1.2	8.3	Cloudy	Grey
June 21	10:30	L 03:55 H 16:10	0.0	17.7	Sunny	Grey
June 26	10:30	L 08:10 H 14:10	20.4	11.3	Rain	Grey
July 4	10:30	H 09:25 L 15:50	0.0	17.9		
July 11	10:30	L 08:50 H 14:50	3.3	16.6	Rain	Grey
August 7	11:00	L 06:25 H 12:15	0.0	20.9	Sunny	Grey
August 15	10:00	H 07:15 L 13:15	0.0	22.9	Sunny	Grey

*L=Low, H=High

The stations located at the mouth of the Basin and within the Narrows are the most turbid of the sites, due to the suspended matter from the Basin and the outfalls located within the Narrows. There was a definite colour difference from the shoreline waters to mid-harbour, indicating dissipation from the outfalls to the reference sites. The colour of the waters of the reference sites had not returned to the background conditions of the seawater outside the Harbour. On occasions surface slicks consisting of sewage scum, oils and greases extended from the outfalls to the reference sites .

Few floatables such as personal hygiene products, prophylactics, driftwood and garbage bags were observed, especially after storms. Buoys anchored within the Harbour were covered with sewage fungus and brown seaweed.

Odour associated with the Harbour waters was minimal in comparison to the outfall locations; but noticeable in comparison to the seawater outside the Harbour.

Section 5.6 ANALYSIS OF CORE SAMPLING DATA

Organic and inorganic particles originating from raw sewage, which settle to the bottom forming a sludge layer are one of the major mechanisms of waste decomposition. The bacterial content of the sewage is the only means of waste stabilization, first removed by temperature and salinity shock. Later, the clumping procedure precipitates these bacteria and organics to the sediments, where the dissolved oxygen content is lacking. The toxic contents of the sediment as well as the toxic products resulting from phytoplankton and diatom activities present in the sediment and the water column are other eliminating mechanisms. Although sedimentation of "clumped organics" plays an important role in bacterial survival, most of the coliforms die away at this point because of the dissolved oxygen deprivation as well as other mechanisms. Discharge of a high load of material from the outfalls in the area can also increase the die-off rate of other aerobic bacteria and enhances the presence of anaerobic conditions. Toxic substances in the sewage become the limiting factor in the survival of any microorganisms within the sludge banks.

The submerged sewage pipes eliminate the hygienic impact of wind-induced seaspray (Sterregaard, 1974). However, the discharge of effluents at the level of sediments increases the size of the sludge banks and enhances undesirable anaerobic conditions, since the velocity of the current is lower in the bottom layers of the plume waters than at the surface. The jet of effluent water from the outfall pipe is the mechanism by which the solid content of the sewage is being deposited anywhere between 3 to 100 meters from the point of discharge, depending on the water depth and the force of the jet of sewage and velocity of water circulation mechanisms.

The level of settleable solids in every case, is a function of the size, distribution, specific gravity and cohesiveness of the contaminants to naturally occurring materials, velocity of the displacement and the characteristics of the outfall area. In an area where the sea bed comprises of rocks and coarse grain sediments, the sludge particles have a better opportunity to trickle through the coarse material as well as to decompose, if other undesirable conditions do not exist. Whereas, solids accumulate more readily on clay, sand, silts and mudflats.

The sludge banks are also the holding grounds for undesirable contaminants such as heavy metals, DDT, PCB and radioactive material. A survey of the various oceans and seas of the world have revealed that the mercury, chemical compounds and heavy metal content of fish and shellfish have increased an average of 3 fold during the last decade (A. Svannson, 1974).

The aspect of oxygen uptake of the sludge deposits for waste stabilization was raised on several occasions. Dissolved oxygen levels within the first half meter from the sludge appear to be lower than through the water column. As a result the water samples were taken beyond this half meter limit; and the meter readings of the water column were carried out in the same vicinity. Even though, the deposits were to be stabilized by the biological assimilation of the waste, the aerobic decomposition in this case was only present in the first few centimeters of the surface sludge deposit.

The monitored outfalls showed that the majority of the deposits were undergoing a very slow anaerobic decomposition. In this case, the product of anaerobic activity of microorganisms diffuse upward through the water column. The soluble end-products, organic acids, organic salts as well as methane gas and hydrogen sulphide escape the sludge banks and diffuses upward to the surface. This gas escaping the sludge layers, lifts sludge pieces to the surface. However, it is important to note that, most of the chemicals present in, or produced by the sludge, are trapped below a relatively strong pycnocline (density jump) in the deeper sections. As a result of a turbulent activity in the chemical supernatant trapped below the pynocline is mixed and removed (Sterregaard, 1974). Therefore, in all the outfalls, the presence of hydrogen sulphide denoted the existence of anaerobic condition. Further tests for insoluble and soluble nitrogenous, phosphorous and carbonaceous material are needed to estimate the contribution of the sludge banks to the nutrient enrichment and biological impact of the sludge deposits.

The observations made on the sludge deposits of Halifax Harbour, resulted from the analysis of a core sampling program conducted in the summer of 1985. Benthic samples were retrieved using a core sampler (Photoplate #14). Six outfall areas and 19 samples were collected the results are recorded in Table 5.30. Each site will be discussed in accordance to the above relevant facts.

It is important to note that the data presented indicates the depth of the dewatered sludge; as a result, the actual depth of the sludge was greater than the value of the compacted samples reported here.

From the analysis of the core sampling results, various new aspects of the impacts of raw sewage were examined. However, it is clearly evident that this data was only analyzed on the basis of the visual observations of the sludge, and a quantitative study of the sediments and sludge would provide a more comprehensive answer to the contents of the sediment.

Tufts Cove

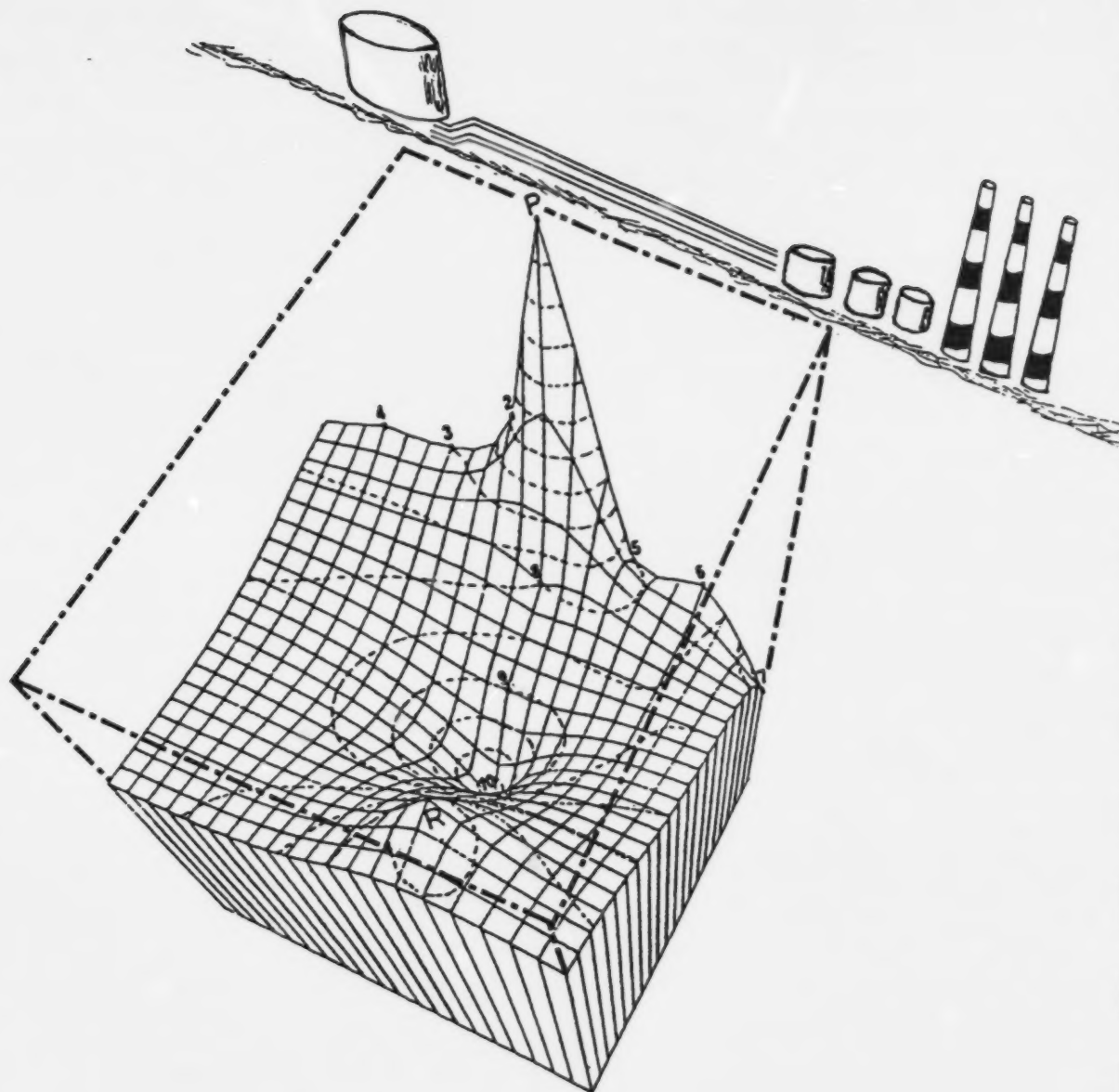
Three core samples were collected from this area at distances of 50, 100 and 150 meters and the depth of the sludge and the contents are recorded in Table 5.30. Photoplate 16, shows the depth of the sludge at station 9, 100 meters from the outfall. Map 3.13 shows the bottom configuration resulted from the sludge bank formation.

Sludge depths decreased with distance from the outfall, indicating the deposition of the organic and inorganic materials in the close proximity of the discharge point. In photoplate 5, the sludge bank is visible at lowtide indicating rapid precipitation of the sewage particles at the point of discharge.

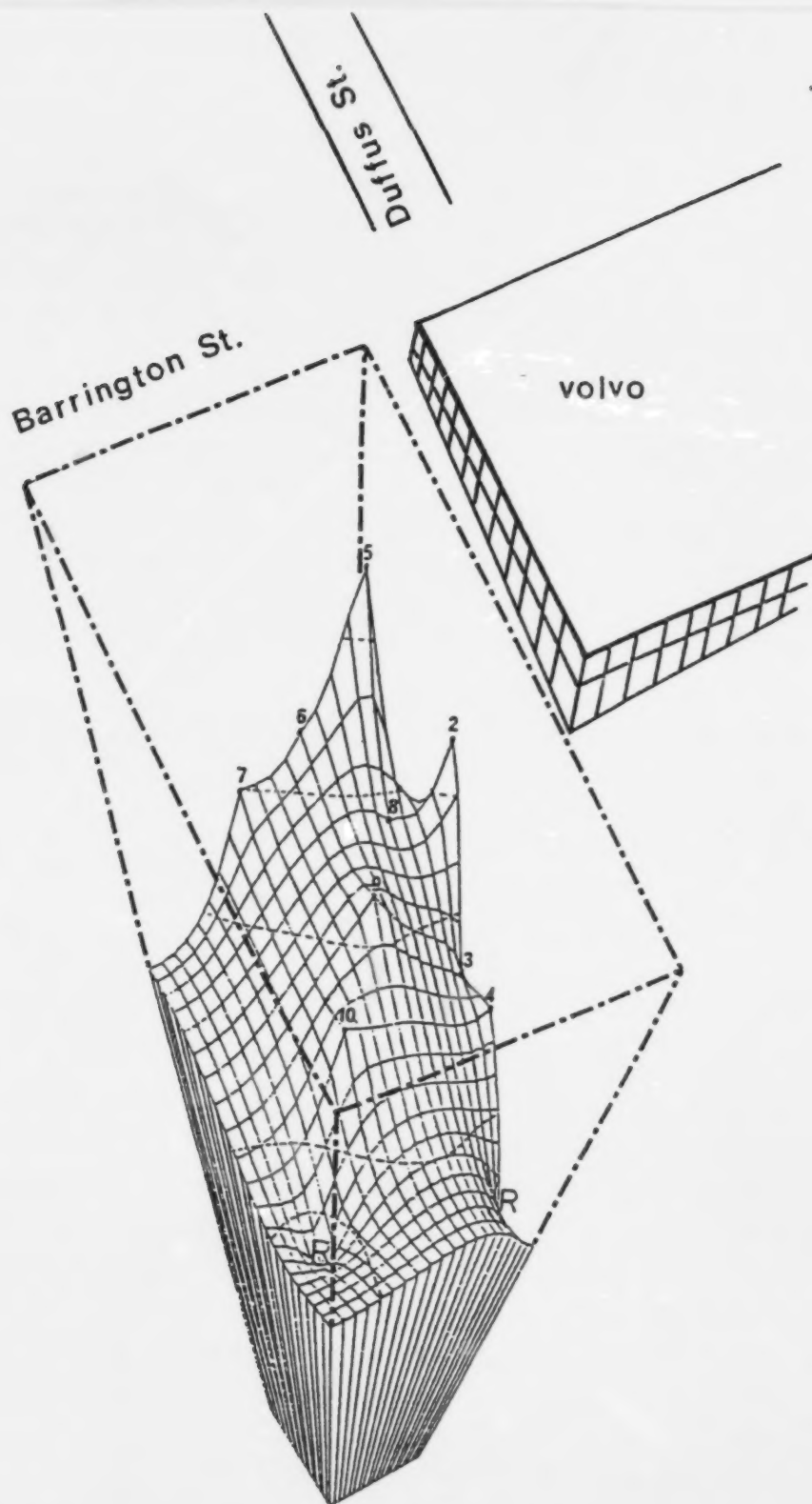
Duffus Street

Three core samples were collected from the Duffus Street area at distances of 50, 100 and 150 meters from the outfall, the depth of sludge and its contents are recorded in Table 5.30. Photoplate 15, shows the depth of sludge at station 10, 150 meters away from the outfall. Map 3.14 shows the bottom configuration caused by sludge deposition.

The depths of the sludge at the 50 and 150 meter distances were 50 cm, indicating an accumulation of sludge at all stations. The 100 meter station showed a slightly higher depth of sludge than the other stations, indicating an increased accumulation of matter at this point.



MAP: 3.13 BOTTOM CONFIGURATION OF THE OUTFALL AREA AT TUFTS COVE.



MAP: 3.14 BOTTOM CONFIGURATION OF THE OUTFALL AREA AT DUFFUS STREET.

The depth of sludge was greater at Duffus Street than at Tufts Cove, because of a higher load of sanitary sewage emanating from Duffus Street. On the other hand, the strong jet of sewage as well as an active and turbulent water movement could be the mechanisms significant in sludge movement from Duffus Street outfall area.

Dartmouth Cove

Four core samples were collected from this area and the distances, sludge depth and contents of the sludge are recorded in Table 5.30. Photoplate 17, shows the depth of sludge at station 8, 100 meters from the outfall.

The large, uniformly distributed and loosely packed sludge accumulation in the Cove was due to the lack of current. The relative shallowness and low sewage discharge velocity were the other mechanisms effecting the accumulation rate of the sludge in the Cove.

Sackville Street

Four core samples were collected from this area and the distances, sludge depths and contents of the sludge are recorded in Table 5.30.

The major accumulation of organic material occurred at a distance of 75 meters, and decreased with distance from the outfall. The high velocity of the jet of sewage was the reason for the distance of sludge settlement. There also appeared to be an active level of sediment movement in progress since the depth of the sludge bank decreased rapidly. Extent of the outspread of the sludge bank was not quantified. However, within 200 meters from the point of discharge the thickness of the sludge layer was reduced to 20 cm.

Pier "A"

Three core samples were collected from this area, the distances, sludge depths and contents are recorded in Table 5.30.

The accumulation of sludge was concentrated within the Pier, because of the lack of current and water movement the major portion of the materials

settle before reaching the end of the Pier. Low velocity of the sewage that was being discharged was another reason for the accumulation of the sludge within the Pier. The lack of sludge at station 5, was due to active, strong current movement flowing through the area.

Summary

The movement of the sludge and sediments to the middle of the Harbour had not been measured; but there is a need for an estimate of the sludge deposits in this area. Even though, Halifax Harbour has been dredged within the last 20 years; a measure of the depth of the sludge banks and the Sackville River sediment deposits into the Basin as well as sediment movement through the Narrows are necessary. An estimate of the sludge and sediment quantity in the Harbour would provide a basis for deciding the amount of the sludge that is carried away from every outfall site.

Therefore, there are variable sized sludge banks present in the outfall areas. The extent of their intrusion into the middle of the Harbour is not known. There is a need for estimation of the sediment and the sludge movement. Velocity of the jet of sewage and current decides the fate, distance and rate of sludge bank formation and removal. Aerobic decomposition was observed to be low, and anaerobic conditions existed in every outfall area, however, the sharp oxygen reductions were only present in a half meter of the water column (observation from the daily data, available from N.S.D.O.E). The soluble supernatant of the sludge by-products was observed to effect up to 4 meters of the bottom waters.

TABLE 5-30 THE RESULTS OF CORE SAMPLING FOR THE STATIONS CLOSE TO THE OUTFALLS
IN HALIFAX HARBOUR

LOCATION	STATION	DISTANCE FROM THE PLUME	SLUDGE DEPTH*	OBSERVATION OF THE SLUDGE CONDITION
DUFFUS	8	50 m	50 cm	Black coloured, viscous sludge containing personal hygiene items, few shells, sand and silt. Sludge had a foul smell with 3-5 cm of fluffy, black and aerobically active material on the surface layer.
	9	100 m	60 cm	
	10	150 m	50 cm	
TUFTS CUBE	8	50 m	42 cm	Oily, black coloured sludge contains personal hygiene material, human hair, decomposing food, sand, silt, large pebbles and pockets of oily residue. Very odorous sludge had thin layer (1-3 cm) of aerobically active material on the surface.
	9	100 m	35 cm	
	10	150 m	23 cm	
DAKIN/MTW CUBE	5	50 m from Plume 2	50 cm	Dense, black sludge comprised of personal hygiene material, decomposing food, sand and silt. Five cm of lightly packed aerobic particles were present in the sludge-water interface. A distinct sanitary sludge smell was present.
	7	50 m from Plume 1	55 cm	
	8	100 m from Plume 1	46 cm	
	9	150 m from Plume 1	40 cm	
PIER A	2	300 m from Plume 1	40 cm	Viscous, black coloured organics composed of personal hygiene material, decomposing food, grain, sand, silt and 3-5 cm of fluffy, black aerobically active material. Sludge core had a foul odour.
	3	50 m from Plume 2 and 450 m from Plume 1	25 cm	
	5	50 m	0 cm	
SACKVILLE STREET	1.5	50 m	16 cm	Compact, black coloured sludge contains plant material, shells, personal hygiene materials, decomposing food, sand and silt; with a thin layer (1-3 cm) of aerobically active materials present. Sludge was very odorous.
	2	75 m	55 cm	
	3	140 m	37 cm	
	4	200 m	20 cm	
HISTORIC PROPERTIES	-	50 m (east)	30 cm	Black coloured organic sludge containing personal hygiene particles, plant material and 2 cm of aerobically active particles on the surface.
	-	100 m (south)	0 cm	

* To the level of silt (without water).

Section 5.7 Regression Analysis of the Daily Field and Laboratory Data

To identify the interrelationship between the various components of wastewater quality parameters, linear regression analysis was carried out on the daily, monthly and annual data. On a annual basis the field and laboratory parameters had very low correlations which was expected considering the variable flow rates, source strengths, water circulation patterns in the Harbour waters and other complexing factors. The multiple regression analysis of the monthly data yielded the results presented in Tables 5.31 to 5.39 for laboratory and field data. Multiple regression analysis of the daily data are available from N.S.D.O.E.. A strong correlation between the daily and monthly regression equations have been established.

Field Data

A variable correlation between all the parameters was established, but these relations were not significant to be reported.

The regression analysis indicated that salinity and conductivity were best predicted during the summer season. Better correlations existed between the parameters measured in the field, for the outfall areas more accessible to general Harbour water circulation (i.e. Duffus Street and Sackville Street).

To verify the capability of these formulas in predicting the concentration of these parameters the sample calculations were carried out. The calculations resulted from the tabulated formulae and even those not reported, since they had r-squared less than 80%, provided a good estimate of the field parameters.

Laboratory Data

The results of all the laboratory parameters were correlated and the significant relations were pursued and reported. The single and multiple regressions indicated a very good relation of suspended solids with other

TABLE 5-31 REGRESSION ANALYSIS OF FIELD DATA FOR TUFTS COVE, 1985

PREDICTION OF	MONTH	BASED ON	FUNCTION	R SQUARED	DEGREE OF FREEDOM
Conductivity Salinity	August	D.O., Temp., Salin.	Cond. = $15.8 + .968(D.O.) + 6.18(Temp.) + 8.02(Salin.)$	83.4	42
		D.O., Temp., Cond.	Salin. = $7.4 - .0709(D.O.) - .648(Temp.) + .0885(Cond.)$	83.6	42

TABLE 5-32 REGRESSION ANALYSIS OF FIELD DATA FOR DUFFUS STREET, 1985

PREDICTION OF	MONTH	BASED ON	FUNCTION	R SQUARED	DEGREE OF FREEDOM
Conductivity	May	temp., salin.	Cond. = $-18.7 + 8.57(temp.) + 8.75(salin.)$	87.6	96
Conductivity	June	temp., salin.	Cond. = $-12.1 + 9.30(temp.) + 12.2(salin.)$	85.4	97
		D.O., temp., salin.	Cond. = $-131 + 1.42(D.O.) + 9.51(temp.) + 12.1(salin.)$	85.5	96
Salinity		D.O., temp., cond.	Salin. = $12.9 + .0583(D.O.) - .732(temp.) + .0693(cond.)$	91.8	96
Conductivity	July	D.O., temp., salin.	Cond. = $-95.7 + 4.10(D.O.) + 8.82(temp.) + 10.4(salin.)$	88.2	96
		D.O., temp., cond.	Salin. = $11.1 - .0291(D.O.) - .807(temp.) + .0816(cond.)$	96.9	96
Conductivity	August	D.O., temp., salin.	Cond. = $-1.46 + .446(D.O.) + 7.17(temp.) + 8.30(salin.)$	88.8	96
		D.O., temp., cond.	Salin. = $5.29 + .0401(D.O.) - .722(temp.) + .0949(cond.)$	88.1	96

TABLE 5-33 REGRESSION ANALYSIS OF FIELD DATA FOR DARTMOUTH COVE, 1985

PREDICTION OF	MONTH	BASED ON	FUNCTION	R SQUARED	DEGREE OF FREEDOM
Conductivity	April	Salin.	$\text{Cond.} = 24.2 + 7.92(\text{Salin.})$	82.4	55
Salinity		Cond.	$\text{Salin.} = 3.11 + .104(\text{Cond.})$	82.4	55
Conductivity		D.O., Temp., Salin.	$\text{Cond.} = 21.9 + .200(\text{D.O.}) + .196(\text{Temp.}) + 7.91(\text{Salin.})$	82.4	53
Salinity		D.O., Temp., Cond.	$\text{Salin.} = 12.8 + .0578(\text{D.O.}) - 1.09(\text{Temp.}) + .0734(\text{Salin.})$	87.5	53
Conductivity	May	D.O., Temp., Salin.	$\text{Cond.} = -10.0 + .346(\text{D.O.}) + 7.60(\text{Temp.}) + 8.64(\text{Salin.})$	85.7	56
Salinity		D.O., Temp., Cond.	$\text{Salin.} = -7.56 + .0686(\text{D.O.}) - .979(\text{Temp.}) + .0927(\text{Cond.})$	94.7	56
Conductivity	June	Salin.	$\text{Cond.} = 26.6 + 9.71(\text{Salin.})$	82.2	50
Salinity		Cond.	$\text{Salin.} = 2.47 + .0847(\text{Cond.})$	82.2	50
Conductivity		D.O., Temp., Salin.	$\text{Cond.} = 40.1 - 9.95(\text{D.O.}) + 3.37(\text{Temp.}) + 10.9(\text{Salin.})$	85.4	48
Salinity		D.C., Temp., Cond.	$\text{Salin.} = 1.21 + .987(\text{D.O.}) - .441(\text{Temp.}) + .0771(\text{Cond.})$	88.1	48
Temperature	July	D.O., Salin., Cond.	$\text{Temp.} = 30.1 - .426(\text{D.O.}) - .89(\text{Salin.}) + .0247(\text{Cond.})$	80.0	55
Salinity		D.O., Temp., Cond.	$\text{Salin.} = 24.5 + .0089(\text{D.O.}) - .837(\text{Temp.}) + .0383(\text{Cond.})$	82.4	55
Salinity	August	D.O., Temp., Cond.	$\text{Salin.} = 281 + 1.69(\text{D.O.}) + 3.94(\text{Temp.}) + .0005(\text{Cond.})$	80.7	54

TABLE 5-34 REGRESSION ANALYSIS OF FIELD DATA FOR PIER A, 1985

PREDICTION OF	MONTH	BASED ON	FUNCTION	R SQUARED	DEGREE OF FREEDOM
Salinity	February	D.O., temp., cond.	$\text{Salin.} = 31.3 - .115(\text{D.O.}) - .791(\text{temp.}) - .0007(\text{cond.})$	80.3	42
Temperature		D.O., salin., cond.	$\text{Temp.} = 32.1 - .196(\text{D.O.}) - .988(\text{Salin.}) - .0010(\text{cond.})$	84.9	42
Salinity	July	D.O.	$\text{Salin.} = -7.35 + 4.78(\text{D.O.})$	81.6	44
Salinity		D.O., temp., cond.	$\text{Salin.} = 9.36 + 2.22(\text{D.O.}) - .544(\text{temp.}) + .0258(\text{cond.})$	90.9	42
Salinity		temp., salin., cond.	$\text{D.O.} = 1.97 - .0034(\text{temp.}) + .15(\text{salin.}) + .0043(\text{cond.})$	82.8	42
D.O.		D.O., cond.	$\text{Salin.} = -9.30 + 4.48(\text{D.O.}) + .0135(\text{cond.})$	82.0	43

TABLE 5-35 REGRESSION ANALYSIS OF LABORATORY DATA FOR TUFTS COVE, 1985.

PREDICTION OF	MONTH	BASED ON	FUNCTION	R SQUARED	DEGREE OF FREEDOM
S.S.	June	BOD, COD, H ⁺	S.S. = $7.79 + .701(\text{BOD}) + .0225(\text{COD}) + (1.33\text{E} - 08)(1/\text{H}^+)$	79.5	54
S.S.		BOD, COD	S.S. = $9.67 + .719(\text{BOD}) + .0212(\text{COD})$	79.3	55
S.S.		BOD, H ⁺	S.S. = $12.2 + .742(\text{BOD}) + (1.26\text{E} - 09)(1/\text{H}^+)$	77.4	55
S.S.		BOD	S.S. = $12.4 + .743(\text{BOD})$	77.4	55

TABLE 5-36 REGRESSION ANALYSIS OF LABORATORY DATA FOR DUFFUS STREET, 1985.

PREDICTION OF	MONTH	BASED ON	FUNCTION	R SQUARED	DEGREE OF FREEDOM
S.S.	March	BOD, H ⁺	S.S. = $8.84 + 1.58(\text{BOD}) + (1.98\text{E} - 07)(1/\text{H}^+)$	82.5	55
S.S.	July	BOD	S.S. = $5.62 + 1.47(\text{BOD})$	96.6	56
S.S.		BOD, H ⁺ , COD	S.S. = $3.17 + 1.46(\text{BOD}) + .0056(\text{COD}) + (1.58\text{E} - 08)(1/\text{H}^+)$	96.7	54
S.S.		BOD, COD	S.S. = $5.15 + 1.46(\text{BOD}) + .0051(\text{COD})$	96.5	55
S.S.		BOD, H ⁺	S.S. = $3.79 + 1.47(\text{BOD}) + (1.49\text{E} - 08)(1/\text{H}^+)$	96.7	55

TABLE 5-37 REGRESSION ANALYSIS OF LABORATORY DATA FOR DARTMOUTH COVE, 1985.

PREDICTION OF	MONTH	BASED ON	FUNCTION	R SQUARED	DEGREE OF FREEDOM
S.S.	August	BOD	S.S. = $6.07 + 1.08(\text{BOD})$	94.7	35
S.S.		BOD, COD, H ⁺	S.S. = $8.96 + 1.05(\text{BOD}) + .0079(\text{COD}) - (3.6E - 08)(1/\text{H}^+)$	95.6	33
S.S.		BOD, H ⁺	S.S. = $9.94 + 1.06(\text{BOD}) - (3.7 E - 08)(1/\text{H}^+)$	95.6	34

TABLE 5-38 REGRESSION ANALYSIS FOR LABORATORY DATA FOR SACKVILLE STREET, 1985.

PREDICTION OF	MONTH	BASED ON	FUNCTION	R SQUARED	DEGREE OF FREEDOM
S.S.	March	BOD	S.S. = $32.6 + .385(\text{BOD})$	77.6	32
S.S.	March	BOD, H ⁺	S.S. = $15.4 + .386(\text{BOD}) + (1.7E - 07)(1/\text{H}^+)$	78.8	31
COD	August	BOD, S.S., H ⁺	COD = $136 + 1.33(\text{BOD}) - .0823(\text{S.S.}) - (3.92E - 07)(1/\text{H}^+)$	75.2	19
COD	August	BOD, H ⁺	COD = $136 + 1.20(\text{BOD}) - (3.93E - 07)(1/\text{H}^+)$	75.2	20
S.S.	August	BOD, COD, H ⁺	S.S. = $-.412 + 1.68(\text{BOD}) - .0025(\text{COD}) + (2.08E - 08)(1/\text{H}^+)$	99.5	19
S.S.	August	BOD, COD	S.S. = $3.44 + 1.70(\text{BOD}) - .0127(\text{COD})$	99.5	20
S.S.	August	BOD, H ⁺	S.S. = $-.752 + 1.68(\text{BOD}) + (2.18E - 08)(1/\text{H}^+)$	99.5	20
S.S.	August	BOD	S.S. = $2.44 + 1.68(\text{BOD})$	99.5	21

TABLE 5-39 REGRESSION ANALYSIS OF LABORATORY DATA FOR PIER A, 1985.

S.S.	February	BOD, H ⁺	S.S. = $28.9 + .311(\text{BOD}) + (9.55E - 09)(1/\text{H}^+)$	78.6	16
S.S.		BOD	S.S. = $30.0 + .311(\text{BOD})$	78.5	17
S.S.	March	BOD, H ⁺	S.S. = $44.7 + .307(\text{BOD}) - (1.13E - 07)(1/\text{H}^+)$	78.4	28
S.S.		BOD	S.S. = $33.9 + .366(\text{BOD})$	74.9	29
S.S.	August	BOD	S.S. = $5.43 + .451(\text{BOD})$	75.2	18
S.S.		BOD, COD	S.S. = $3.88 + .408(\text{BOD}) + .0229(\text{COD})$	77.7	17
S.S.		BOD, COD, H ⁺	S.S. = $4.03 + .405(\text{BOD}) + .0230(\text{COD}) - (9.72E - 10)(1/\text{H}^+)$	77.7	16

parameters. As it was predicted, there was not a significant correlation between the concentrations of BOD and COD in the plume waters. The pH values also, did not correlate as well with the other paramaters as was expected.

Except on one occasion the best regressions formulae resulted from the spring and summer data. The laboratory parameters showed better correlation for the Sackville Street outfall area which was more accessible to water circulation but this trend did not prevail for Duffus Street. The regression analysis of Pier "A" data yielded a good correlation in every season. A comparative analysis of this data with the reference values could provide insight into the reasoning for the existence of these conditions.

Summary

The verification process of the formulae, by calculating and comparing experimental values to actual readings, indicated a good estimate of the concentration of contaminants for the given months.

It is conclusive that there still is a need for further statistical analysis of the data provided by this report. Given the limitations of this study only the regression analysis could have been conducted. Generally, these analyses support most of the hypotheses sighted by this report.

PHOTOPLATES



Photo Plate 1: Pier A trunk outfall.

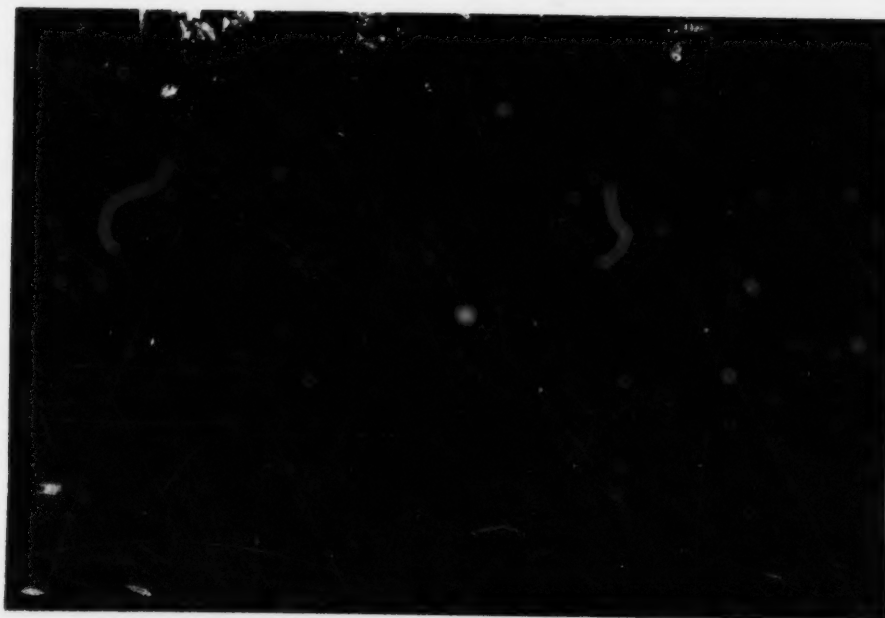


Photo Plate 2: Pier A, 914 mm pipe outfall at lowtide with evident biofouling on wharf.



Photo Plate 3: Dartmouth Cove outfall from Maitland Street

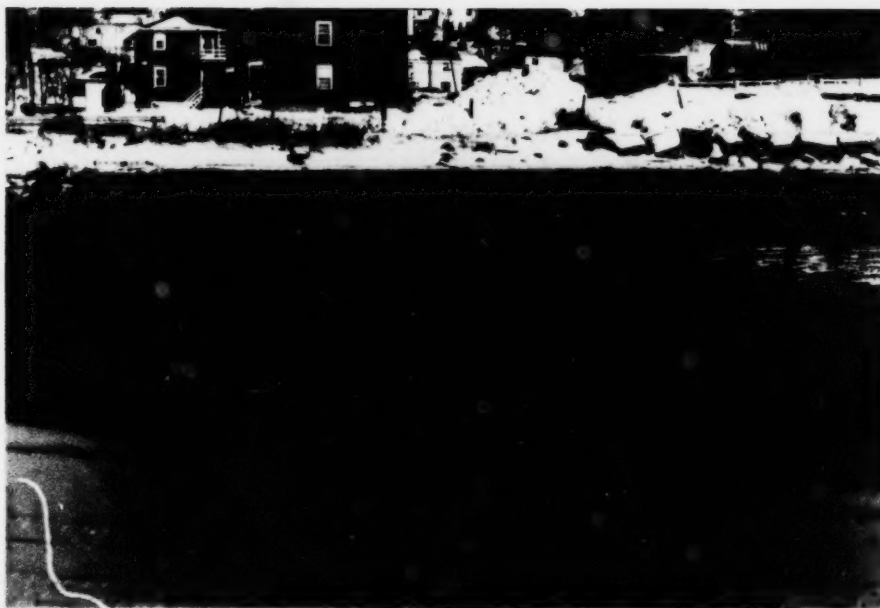


Photo Plate 4: Dartmouth Cove outfall from Old ferry Road.



Photo Plate 5: Tufts Cove outfall at lowtide with sludge banks visible.



Photo Plate 6: Duffus Street outfall at lowtide.



Photo Plate 7: Sackville Street outfall at lowtide with evident biofouling on the pipe supports.



Photo Plate 8: Tufts Cove and Duffus Street suspended solid filters for months of June, July, August and the summer references for stations 2 to 18.

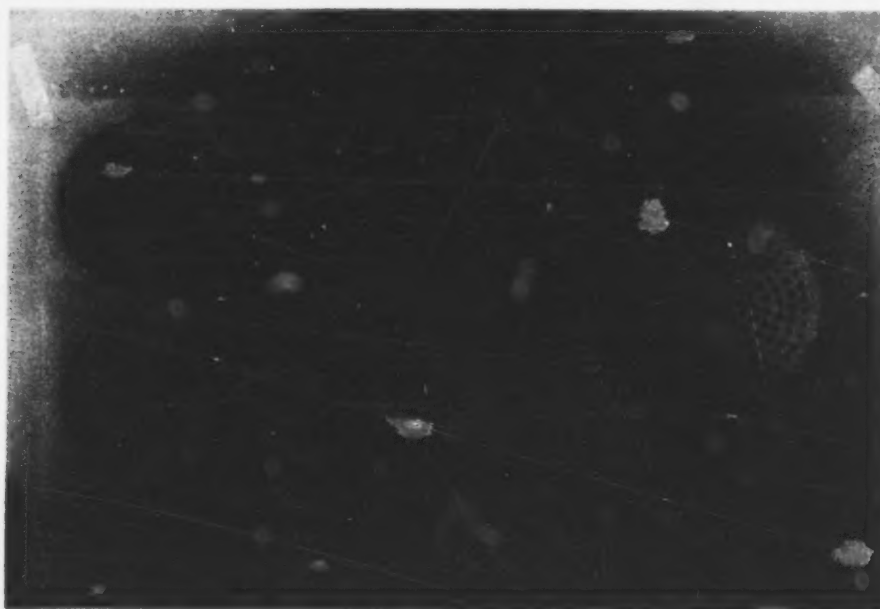


Photo Plate 9: Tufts Cove suspended solid filters for spill of November 28, 1985.

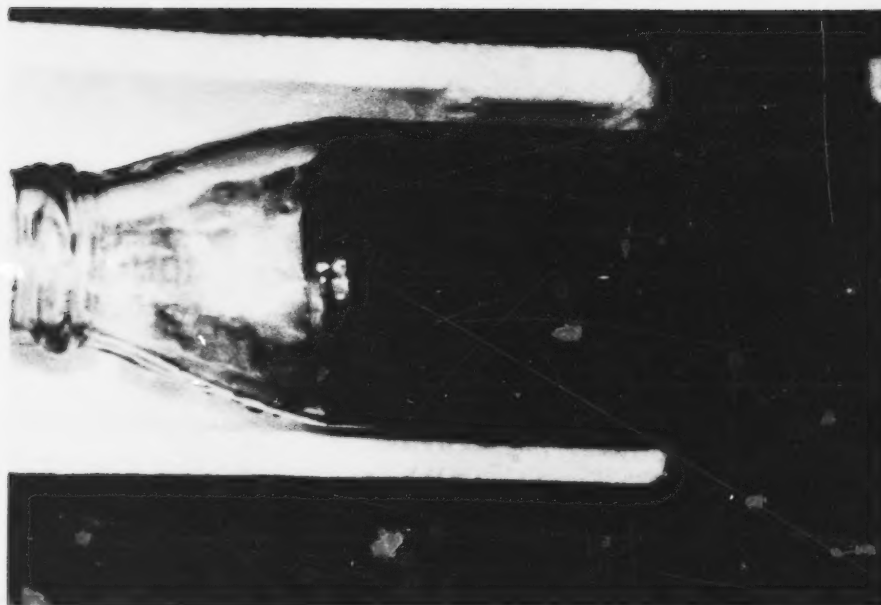


Photo Plate 10: Tufts cove spill sample of November 28, 1985 showing the sample to be very turbid and viscous.

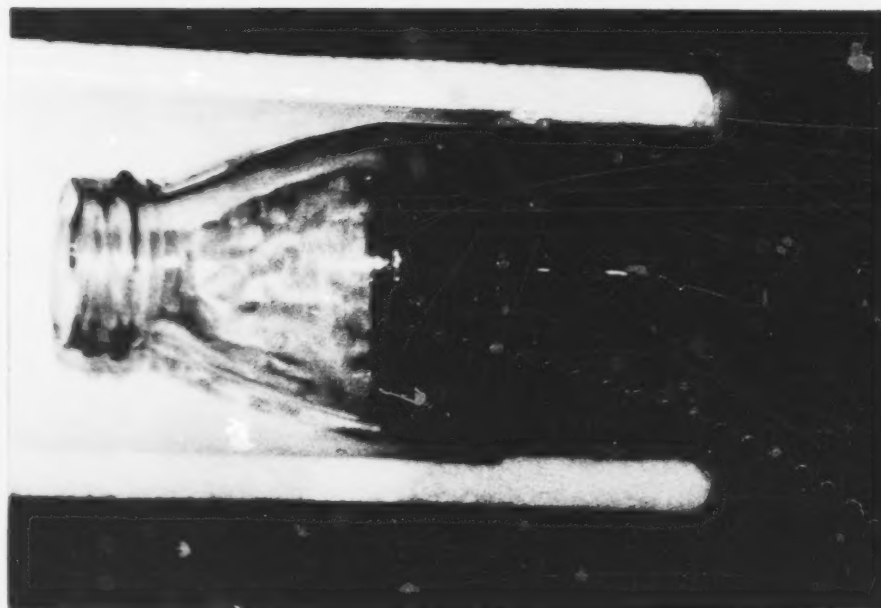


Photo Plate 11: Tufts Cove spill sample showing very turbid conditions.

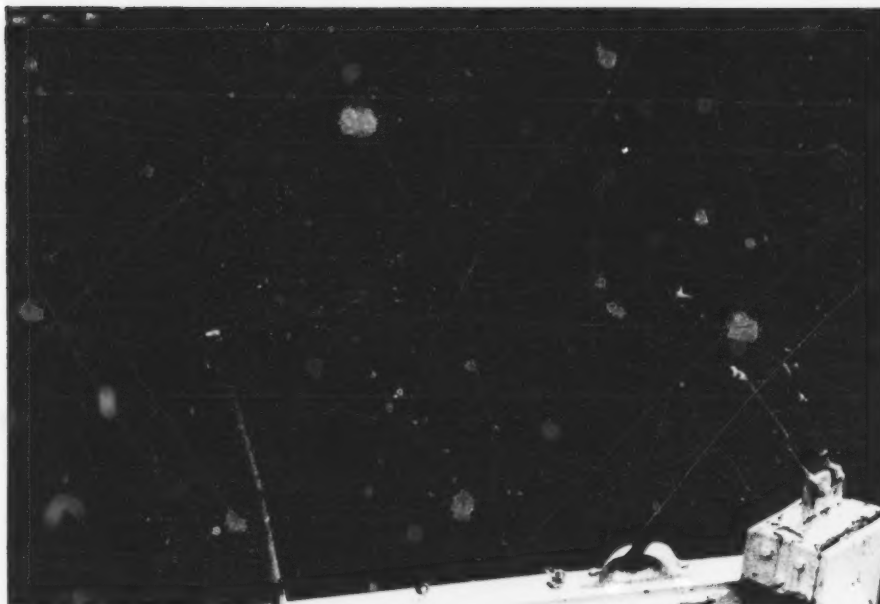


Photo Plate 12: Tufts cove outfall showing discolouration of plume, August 28, 1985.



Photo Plate 13: Tufts cove outfall showing the extent of dispersion of discoloured plume, August 28, 1985.



Photo Plate 14: Core sampler used for sludge study (contributed by Mr. Mike Corveatte of B.I.O.).



Photo Plate 15: Sludge core sampler of Duffus Street at station 10, 150 meters away from the plume.



Photo Plate 16: Sludge core sample of Tufts Cove at station 9,
100 meters away from the plume.

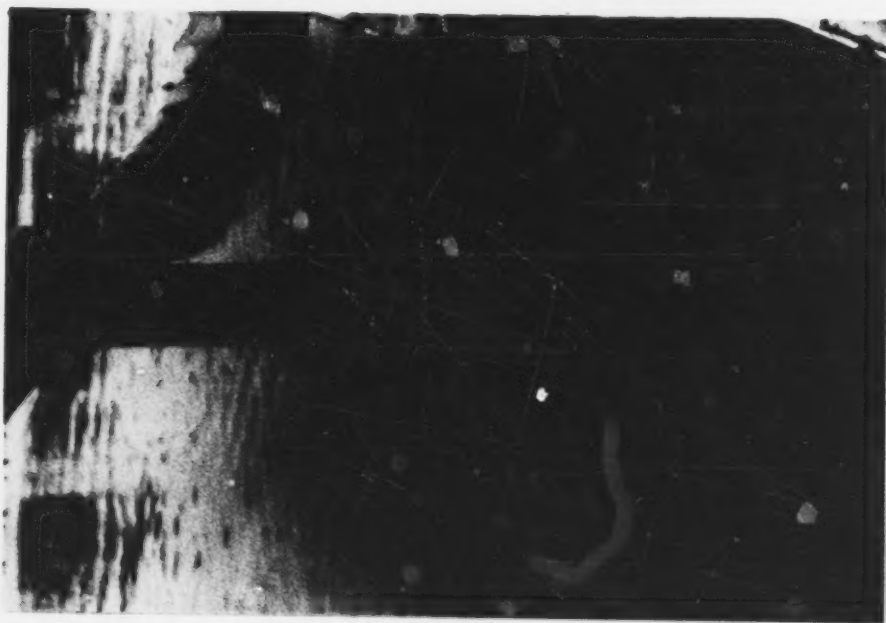


Photo Plate 17: Sludge core sample of Dartmouth Cove at
station 8, 100 meters away from the plume.

APPENDIX A

Halifax Harbour Monthly Field Data

A.I.1. MONTHLY FIELD AVERAGES OF TEMPERATURE (°C), TUFTS COVE, FEBRUARY-AUGUST, 1985

STATION	DEPTH (m)	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
1	0	1.8	1.9	2.7	5.8	9.8	13.5	11.4
2	0	1.7	0.9	2.1	5.4	9.9	14.2	12.3
2	1	1.7	1.5	2.0	4.8	8.5	13.0	11.1
2	2	1.5	1.0	1.9	4.3	7.4	9.9	11.1
2	3		0.9	1.6		5.8	8.8	5.8
2	4						7.1	5.9
3	0	2.0	0.8	2.1	6.1	10.0	14.9	10.9
3	1	2.0	1.3	2.1	5.5	8.3	14.0	9.7
3	2	2.0	1.1	1.9	4.6	7.1	9.0	9.2
3	3	1.5	0.9	1.2	4.5	6.6	8.0	8.8
3	4		0.9	1.0			7.0	5.8
4	0	2.0	1.2	2.1	6.5	10.0	15.2	11.0
4	1	1.9	0.8	2.0	5.1	8.5	14.0	10.4
4	2	1.9	0.8	1.7	4.5	7.3	9.0	9.4
4	3	1.9	0.7	1.4	4.4	7.1	8.0	8.9
4	4	1.9	0.8	1.1	4.3	6.9		6.0
5	0	1.9	1.8	2.2	4.3	8.6	16.9	12.0
5	1	1.6	1.8	1.8	5.2	8.0	14.5	11.6
5	2	2.0	1.7	1.6	4.6	7.0	9.2	11.0
5	3	1.8	1.5	1.5	4.3	5.8	7.7	10.6
5	4	1.6	1.1	1.1	4.5	5.3	7.0	

cont'd

5	5	1.5	1.0	1.1	5.8	9.6	15.4	12.1
6	0	2.2	1.9	2.2	4.7	8.7	14.2	11.1
6	1	2.2	1.9	2.0	4.5	7.1	10.5	10.9
6	2	2.2	2.3	1.9	4.2	6.1	6.9	10.5
6	3	1.8	1.6	1.8	4.4	5.7	6.2	8.7
6	4	1.6	1.4	1.2				
6	5	1.1	1.9	1.1	5.4	9.8	15.0	12.1
7	0	3.0	1.9	2.3	4.9	9.2	14.0	11.0
7	1	3.0	1.9	2.4	4.6	8.1	13.8	10.9
7	2	2.6	1.7	2.4	3.9	7.0	8.9	10.7
7	3	2.3	1.3	2.0	3.8	5.9	7.0	8.7
7	4	1.8	1.0	1.5		5.3	6.2	
7	5	1.5	0.8	1.6			5.0	
7	6	1.5	0.8	1.6				
7	7		0.5	1.5	5.7	10.0	14.2	12.3
8	0	2.5	2.0	2.1	5.2	8.7	14.0	11.4
8	1	2.1	2.0	1.5	4.9	7.1	12.5	11.3
8	2	2.4	1.9	1.4	4.6	6.5	8.0	10.7
8	3	2.9	1.3	1.3	3.5	6.0	7.0	10.1
8	4	2.0	1.1	1.2		5.6	6.0	
8	5		1.1	1.2				
8	6		1.0	1.0				
8	7		1.0	1.0				
9	0	3.0	1.6	2.0	5.6	9.4	14.0	11.5
9	1	2.5	1.7	1.6	5.0	9.0	13.0	11.4
9	2	2.1	1.8	1.2	4.5	7.1	12.0	11.3
9	3		1.3	1.3	5.0	6.3	9.0	10.8
9	4		1.2	1.1		5.8	7.0	10.1
9	5		1.0	1.0		5.3	6.0	8.9
9	6		0.9	0.9			5.0	
9	7		0.9	0.9				
9	8		0.9	0.9				
10	0	2.7	1.7	2.0	5.4	9.4	15.0	11.9
10	1	2.1	1.7	2.0	4.5	8.3	13.1	12.0
10	2	2.0	1.9	1.9	4.4	7.1	12.2	11.6
10	3	2.0	1.6	1.3	3.8	6.7	11.0	11.4
10	4		1.1	1.0	3.6	5.9	7.0	10.2
10	5		1.1	0.9	4.0	5.5	6.2	10.0
10	6		0.9	1.0	3.9	5.2	5.2	
10	7		0.9	1.0	3.9	4.6	4.5	
10	8		0.9	0.8	3.0			
10	9		0.9	0.8	3.0			

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	4.1	4.0	3.8	9.5	10.9	16.9	16.0
minimum	1.0	0.0	0.5	2.1	2.1	4.5	4.5
stan.dev.	0.6	0.9	0.7	2.1	2.7	3.6	3.3
average	2.0	1.4	1.6	4.6	7.1	10.3	10.5
skewness	n	+	+	+	-	+	-

n = normal distribution

[illegible]

p, .01

3	10	0.5	0.5	1.1	2.5	2.3	5.3	10.3
4	0	0.7	0.7	2.0	5.3	8.8	12.2	14.3
4	1	0.7	0.7	1.9	5.0	7.5	11.7	13.6
4	2	0.8	0.6	1.7	4.8	6.2	10.8	13.4
4	3	0.8	0.5	1.5	4.0	6.0	8.9	12.1
4	4	0.8	0.5	1.4	3.2	5.8	7.9	11.9
4	5	0.8	0.5	1.4	2.9	5.5	6.4	11.3
4	6	0.7	0.5	1.3	2.9	5.5	5.7	11.2
4	7	0.7	0.5	1.3	2.7	5.0	5.5	11.0
4	8	0.7	0.5	1.3	2.6	4.8	5.4	10.8
4	9	0.7	0.5	1.2	2.6	4.5	5.3	10.5
4	10	0.8	0.4	1.0	2.5	3.1	5.1	10.7
5	0	1.1	1.4	2.5	5.3	6.6	12.2	13.6
5	1	1.0	1.3	2.0	5.2	5.9	12.1	13.5
5	2	0.9	1.1	1.8	4.7	5.8	11.3	13.3
5	3	0.9	0.9	1.6	4.3	5.5	9.2	11.5
5	4	0.8	0.8	1.4	3.7	5.4	8.0	11.1
5	5	0.8	0.8	1.3	3.4	5.4	7.0	10.8
5	6	0.8	0.7	1.3	3.2	5.1	6.5	10.5
5	7	0.7	0.7	1.3	2.9	5.0	5.7	10.1
5	8	0.7	0.6	1.2	2.7	3.0	5.5	9.8
5	9			0.5	2.7	2.6	5.3	9.5
5	10			0.5	2.6	1.5	4.8	9.2
6	0	1.3	1.1	2.1	5.5	7.4	12.9	13.3
6	1	1.1	1.0	2.0	5.0	6.0	11.5	13.0
6	2	1.0	0.9	2.0	4.5	6.0	9.1	12.0
6	3	1.0	0.9	1.9	4.2	5.8	8.5	11.8
6	4	0.9	0.8	1.5	3.7	5.5	7.8	11.2
6	5	0.9	0.8	1.4	3.1	5.5	6.6	10.6
6	6	0.8	0.7	1.4	3.0	5.1	6.1	10.5
6	7	0.8	0.7	1.3	2.7	4.3	5.5	10.0
6	8	0.8	0.7	1.2	2.6	4.0	5.3	9.4
6	9	0.8	0.7	0.7	2.5	2.5	5.3	9.0
6	10	0.7	0.7	0.7	2.5	2.0	5.1	8.8
7	0	1.8	1.2	2.1	5.4	7.1	12.8	14.5

cont'd

7	1.2	1.0	2.0	5.1	6.2	11.4	13.5
7	1.0	1.0	1.9	4.9	5.6	10.1	13.0
7	0.9	1.0	1.6	4.2	5.6	8.5	12.0
7	0.9	0.9	1.5	3.7	5.5	7.8	11.7
7	0.8	1.0	1.4	3.1	5.0	6.6	12.0
7	0.8	1.0	1.4	3.0	5.0	6.0	11.1
7	0.9	1.0	1.2	2.8	4.9	5.7	10.6
7	0.9	0.9	1.1	2.7	3.5	5.5	9.8
7	0.9	0.9	1.0	2.6	2.2	5.3	9.5
7	0.9	0.9	0.6	2.5	2.0	6.3	9.2
7	2.0	1.5	2.4	5.2	7.1	12.0	13.5
8	1.3	1.2	2.1	5.1	6.2	11.6	13.0
8	1.1	1.2	1.8	4.2	5.6	10.9	12.1
8	1.0	1.1	1.6	4.0	5.6	9.0	11.5
8	1.0	1.1	1.5	3.6	5.5	7.7	10.9
8	1.0	1.0	1.4	3.2	5.0	6.5	10.7
8	1.0	0.9	1.3	2.9	5.0	5.7	10.8
8	1.0	0.9	1.2	2.8	4.9	5.4	10.0
8	1.0	0.9	1.1	2.6	3.5	5.4	9.9
8	1.0	1.0	1.0	2.5	2.2	5.3	9.9
8	1.0	1.0	1.0	2.5	2.0	5.2	9.5
9	1.4	1.4	2.3	5.5	7.3	12.7	13.8
9	1.3	1.3	2.0	5.2	7.0	11.9	13.7
9	1.1	1.1	2.0	4.3	6.1	10.3	13.2
9	1.1	1.1	1.6	3.8	6.0	9.0	11.9
9	1.1	1.1	1.4	3.5	5.8	8.2	11.5
9	1.0	1.0	1.4	3.1	5.5	6.9	11.1
9	1.0	1.0	1.2	3.0	5.2	6.5	11.0
9	1.0	1.2	1.2	2.8	5.1	5.6	10.8
9	1.0	1.1	1.1	2.7	4.3	5.4	10.3
9	1.0	1.0	1.1	2.6	4.0	5.3	10.0
9	0.9	1.0	1.1	2.6	2.0	5.2	9.7
9	1.5	1.2	2.2	5.5	8.3	13.0	14.3
10	1.5	1.2	2.0	5.0	7.7	12.3	13.9
10	1.0	1.2	1.8	4.4	7.0	10.9	12.9
10	1.0	1.2	1.5	4.0	6.0	9.3	11.9
10	1.0	1.1	1.5	3.4	5.7	8.0	11.5
10	1.0	1.1	1.2	3.0	5.5	7.1	11.1
10	1.0	1.1	1.2	2.9	5.0	6.3	11.0
10	1.0	1.0	1.1	2.7	4.5	5.7	10.8
10	1.0	1.0	1.0	2.6	4.1	5.5	10.6
10	1.0	1.0	0.9	2.5	4.1	5.4	10.1
10	1.0	1.0	0.8	2.4	1.9	5.2	9.8

STATISTICAL ANALYSIS OF THE DAILY DATA

max intum	2.0	5.0	7.0	7.5	8.8	14.8	15.0
minimum	0.0	0.0	0.3	1.7	1.5	3.0	7.4
stan.dev.	0.4	0.6	0.8	1.3	1.5	2.9	2.1
average	0.8	0.9	1.5	3.6	5.2	7.9	11.4
skewness	-	-	+	+	-	+	-

A.1.3. MONTHLY FIELD AVERAGES OF TEMPERATURE (°C), DARTMOUTH COVE, FEBRUARY-AUGUST, 1985

STATION	DEPTH (m)	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
1	0	1.5	1.5	2.6	7.8	10.5	10.3	14.5
2	0	0.8	0.8	2.3	7.7	11.8	12.1	15.1
2	1	0.5	0.6	1.9	7.1	10.3	9.8	14.6
2	2	0.4	0.5	1.5	6.1	8.6	8.3	11.4
2	3	0.4	0.5	1.5	5.0	8.2	7.1	10.2
2	4		0.5	1.4	4.6	8.0	6.8	9.9
2	5		0.5		3.0		6.7	
2	6						6.5	
3	0	0.6	0.7	2.1	7.8	11.0	12.0	15.5
3	1	0.6	0.7	1.8	6.6	9.1	9.5	12.5
3	2	0.5	0.6	1.6	5.8	8.4	7.8	12.7
3	3	0.5	0.5	1.4	4.9	8.1	6.9	10.2
3	4	0.5	0.6	1.4	4.3	7.9	6.6	9.3
3	5	0.4	0.6	1.4	3.6		6.5	8.7
3	6		0.6	1.3	3.5			8.0
4	0	0.6	1.1	3.0	8.1	10.3	10.5	15.1
5	0	0.5	0.9	2.1	7.7	11.0	13.1	15.2
5	1	0.5	0.6	1.8	6.4	9.5	9.8	14.0
5	2	0.6	0.5	1.7	6.0	8.1	8.2	11.9
5	3	0.6	0.6	1.7	5.0	7.8	7.5	10.2
5	4	0.6	0.6	1.4	4.4	7.6	6.5	9.6
5	5	0.6	0.6	1.7	3.9	7.5	6.2	9.0
5	6	0.5	0.6	1.3	3.2	7.3		8.6
5	7			1.6	2.7			
5	8							
6	0	1.0	1.3	2.4	8.0	10.6	10.8	15.1
6	1	0.8	1.0	2.0	6.8	9.7	8.9	13.7
6	2	0.7	0.7	1.5	6.8	8.3	7.2	11.0
6	3	0.8	0.7	1.4	4.9	8.1	6.8	10.3
6	4	0.8	0.9	1.4	4.4	7.9	6.7	9.8
7	0	1.2	1.3	2.3	7.4	12.0	12.5	14.7
7	1	0.8	0.8	1.7	6.7	9.5	9.4	13.9
7	2	0.8	0.7	1.5	5.6	8.6	7.8	14.0
7	3	0.8	0.7	1.4	4.7	8.1	6.9	10.8
7	4	0.8	0.7	1.3	4.4	7.8	6.5	9.8
7	5	0.5	0.7	1.3	3.7	7.5	6.4	9.0
7	6	0.4	0.8	1.3	3.5		5.9	8.7

cont'd

8	0	1.0	0.9	1.7	7.8	11.7	12.7	16.1
8	1	1.0	1.1	1.5	6.5	10.0	10.0	14.7
8	2	1.0	0.8	1.4	5.5	8.3	7.6	14.0
8	3	0.9	0.8	1.4	4.5	8.0	6.9	10.0
8	4	0.8	0.8	1.4	4.2	7.7	6.5	9.5
8	5	0.8	0.8	1.4	3.5	7.5	6.3	9.2
8	6	0.4	0.8	1.3	3.1	7.4	6.1	8.7
8	7		0.9		2.7		5.6	8.0
9	0	1.0	1.7	1.9	7.7	11.8	11.0	16.3
9	1	1.0	1.3	1.8	6.2	9.6	9.9	12.3
9	2	1.0	1.0	1.7	5.9	8.3	7.6	12.0
9	3	1.0	1.0	1.4	4.7	7.8	6.9	9.8
9	4	1.0	1.0	1.4	4.3	7.7	6.6	9.3
9	5	1.0	1.0	1.3	3.5	7.5	6.0	9.0
9	6	1.0	1.0	1.3	3.1	7.4	5.9	8.9
9	7	1.2	1.0	1.3	2.6		5.5	8.1
9	8	1.5	1.0				5.5	
9	9						5.5	
10	0	1.0	1.5	1.8	7.1	11.6	12.0	16.0
10	1	1.0	1.1	1.7	6.0	9.3	10.0	14.5
10	2	1.1	1.0	1.7	5.5	8.1	8.0	14.0
10	3	1.1	1.0	1.7	4.7	8.0	6.9	10.4
10	4	1.1	1.0	1.5	4.5	7.7	6.2	9.8
10	5	1.1	1.0	1.4	4.3	7.7	6.3	9.5
10	6	1.0	1.0	1.4	3.4	7.5	5.8	9.0
10	7	1.0	1.0	1.3	3.4	7.2	5.7	8.0
10	8	1.1	1.0		2.8			8.0
10	9	1.5	1.0					

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	1.8	2.6	3.8	10.0	16.2	16.3
minimum	0.0	0.0	0.6	1.5	3.9	8.0
stat. dev.	0.4	0.5	0.6	2.3	2.6	2.6
average	0.8	0.9	1.6	5.1	7.8	11.4
skewness			+	+	-	+

A.1.1.4. MONTHLY FIELD AVERAGES OF TEMPERATURE (°C), SACKVILLE STREET, FEBRUARY-AUGUST, 1985

STATION	DEPTH (m)	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
1	0	1.5	1.8	3.6	7.4	8.9	12.3	13.0
2	0	0.5	0.4	1.8	5.9	8.7	11.9	12.8
2	1	0.5	0.4	1.4	5.7	8.0	11.5	12.0
2	2	0.5	0.4	1.3	5.1	7.5	10.0	11.1
2	3	0.5	0.4	1.3	4.7	7.1	9.1	10.3
2	4	0.5	0.3	1.3	4.1	7.8	8.4	10.0
2	5	0.5	0.2	1.2	3.6	6.6	7.4	9.4
2	6	0.5	0.2	1.2	3.3	6.2	7.1	9.1
2	7		0.2	1.1	2.8	5.9	7.0	8.7
2	8		0.2	1.0	2.5	5.7	6.8	8.3
2	9		0.2	0.9	2.3	5.6	6.8	
2	10		0.1	1.3	2.1	5.0	6.8	
3	0	0.5	0.8	1.6	6.2	8.4	12.2	12.5
3	1	0.5	0.5	1.4	5.7	7.9	11.4	12.7
3	2	0.5	0.5	1.4	5.4	8.0	11.1	11.7
3	3	0.5	0.5	1.3	4.6	7.4	9.5	10.4
3	4	0.5	0.5	1.3	4.4	7.0	9.0	10.1
3	5	0.5	0.5	1.3	3.7	6.6	7.9	10.0
3	6	0.5	0.5	1.3	3.3	6.4	7.2	9.3
3	7	0.3	0.7	1.2	2.7	6.4	7.0	8.9
3	8	0.3	0.5	1.0	2.5	6.1	7.0	8.3
3	9	0.3	0.5	0.9	2.3	6.1	7.0	8.0

cont'd

3	10	0.3	0.4	1.0	2.1	5.6	7.0	7.8
4	0	0.5	0.8	0.8	6.0	8.2	12.2	13.0
4	1	0.5	0.7	1.5	5.8	8.4	11.8	13.0
4	2	0.5	0.7	1.5	5.3	8.0	11.5	11.4
4	3	0.5	0.7	1.3	4.6	7.3	9.8	10.5
4	4	0.5	0.7	1.3	3.6	6.8	8.9	10.0
4	5	0.5	0.7	1.3	3.6	6.8	8.0	9.3
4	6	0.5	0.7	1.2	3.2	6.3	7.5	9.4
4	7	0.5	0.7	1.2	3.1	6.2	7.2	8.0
4	8	0.3	0.7	1.1	2.7	6.1	7.1	7.5
4	9	0.3	0.7	1.0	2.5	5.6	7.0	7.3
4	10	0.3	0.7	0.9	2.2	5.5	7.0	7.0
5	0	0.5	0.9	1.6	6.5	8.7	12.2	13.3
5	1	0.5	0.8	1.4	5.3	8.0	11.7	13.1
5	2	0.5	0.8	1.3	4.9	7.7	9.7	11.6
5	3	0.5	0.8	1.3	4.6	7.2	8.8	10.8
5	4	0.5	0.8	1.3	4.5	7.0	8.4	10.0
5	5	0.5	0.8	1.3	3.8	6.7	7.9	9.6
5	6	0.5	0.8	1.2	3.4	6.5	7.1	9.0
5	7	0.5	0.8	1.1	3.0	6.2	6.9	8.7
5	8	0.5	0.8	1.0	2.5	6.1	6.9	8.5
5	9	0.5	0.8	1.0	2.3	5.8	6.7	8.3
5	10	0.5	0.8	0.8	2.1	5.5	6.6	7.6
6	0	0.5	0.9	1.5	5.9	8.3	11.8	13.5
6	1	0.5	0.9	1.4	5.6	7.9	11.6	12.8
6	2	0.5	1.0	1.3	4.8	7.4	10.8	11.8
6	3	0.5	0.9	1.3	4.4	7.2	9.0	11.5
6	4	0.5	0.9	1.3	4.2	6.9	8.5	10.5
6	5	0.5	0.9	1.3	4.0	6.5	7.3	9.7
6	6	0.5	0.9	1.2	3.9	6.3	7.0	9.4
6	7	0.5	0.9	1.1	3.0	6.2	6.9	8.8
6	8	0.5	0.9	1.0	2.5	5.9	6.8	8.4
6	9	0.5	1.0	0.8	2.3	5.6	6.8	7.9
6	10	0.5	1.0	0.7	2.1	5.3	6.8	7.6

cont'd

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	2.0	2.5	4.0	10.5	11.0	12.9	14.3
minimum	0.0	0.0	0.4	0.9	1.0	6.2	6.1
stan.dev.	0.5	0.4	0.6	1.6	2.6	2.1	2.1
average	0.5	0.7	1.3	4.0	6.8	8.7	10.1
skewness	+	-	+	-	+	+	n

n = normal distribution

A.1.5. MONTHLY FIELD AVERAGES OF TEMPERATURE (°C), PIER A, FEBRUARY-AUGUST, 1985

STATION	DEPTH (m)	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
1	0	3.5	4.8	5.7	7.3	12.0	13.3	14.0
2	0	1.8	2.0	1.8	7.4	9.8	11.8	13.5
2	1	1.1	2.0	1.6	6.2	8.8	11.5	13.5
2	2	0.9	1.9	1.3	5.7	7.5	11.3	13.2
2	3	0.8	1.7	1.3	5.4	6.8	8.7	11.4
2	4	0.9	1.6	1.3	4.7	6.4	8.1	10.1
2	5	0.4	1.6	1.3	3.4	5.9	7.8	9.3
2	6	0.7	1.6	1.2	3.4	5.7	7.7	8.8
2	7	0.6	1.6	1.1	3.0	5.5	7.4	8.3
2	8	0.6	1.6	1.0	2.8	5.3	7.1	8.0
2	9	0.5	1.6	0.9	2.5	5.2	7.0	8.0
2	10	0.5	1.5	0.7	2.4	5.0	6.8	7.7
3	0	1.5	2.8	2.0	6.8	8.6	11.5	14.3
3	1	1.3	2.3	1.4	6.2	8.0	10.4	13.5
3	2	0.9	2.1	1.3	5.7	7.5	9.3	12.7
3	3	0.9	2.5	1.3	4.4	7.1	8.9	11.2
3	4	0.9	2.1	1.2	3.7	6.5	8.3	10.8
3	5	0.9	2.1	1.2	3.3	6.4	8.0	10.5
3	6	0.8	2.1	1.1	3.1	6.3	7.6	9.6
3	7	0.7	2.1	1.1	2.9	6.0	7.4	8.8
3	8	0.7	2.1	1.0	2.7	5.5	7.2	7.5
3	9	0.7	2.2	0.9	2.4	5.2	7.2	7.3

cont'd

3	10	0.5	2.0	0.8	2.0	5.0	7.1	7.0
4	0	4.2	3.5	5.7	7.8	10.8	13.4	6.5
5	0	1.0	2.5	1.9	6.5	8.5	11.5	14.1
5	1	1.0	2.3	1.4	6.2	8.4	10.3	13.5
5	2	1.0	2.2	1.3	5.6	8.2	9.9	12.5
5	3	0.9	0.8	1.2	5.3	7.9	10.4	10.4
5	4	0.9	0.8	1.2	4.5	6.7	8.2	8.9
5	5	0.9	0.8	1.1	3.6	6.5	7.6	8.2
5	6	0.9	0.8	1.1	3.1	6.3	7.3	8.0
5	7	0.8	0.8	1.0	2.8	6.3	7.2	7.8
5	8	0.7	0.7	1.0	2.5	5.8	7.1	7.2
5	9	0.6	0.8	1.0	2.3	5.5	7.0	7.0
5	10	0.6	0.7	0.8	2.2	5.4	7.0	7.0
6	0	2.0	1.0	1.7	6.4	8.7	11.5	13.0
6	1	1.9	0.9	1.5	5.9	8.0	11.3	12.0
6	2	1.9	0.9	1.4	5.4	7.9	9.0	12.8
6	3	1.9	0.8	1.4	4.9	7.0	8.8	10.4
6	4	1.9	0.9	1.2	4.5	6.5	8.1	9.0
6	5	1.9	0.7	1.3	3.9	6.1	7.8	8.5
6	6	1.9	0.8	1.1	3.1	5.9	7.5	8.0
6	7	1.6	0.7	1.1	3.0	5.9	7.4	8.0
6	8	1.5	0.8	1.0	2.8	5.7	7.2	7.2
6	9	1.5	0.6	0.9	2.6	5.1	7.0	6.5
6	10	1.4	0.6	0.8	2.2	4.9	7.0	6.4

cont'd

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	5.4	6.0	12.0	13.0	15.0	15.0
minimum	0.0	0.0	0.5	0.9	6.5	6.4
stan. dev.	1.1	1.2	2.0	3.0	1.9	2.7
average	1.1	1.6	4.2	6.8	8.7	10.0
skewness	-	+	-	+	+	+

5	4	8.9	13.3	11.1	8.8	8.4	7.4	8.5
5	5	9.6	11.4	10.4	9.6	7.8	8.2	9.1
6	0	7.9	9.6	9.8	9.8	7.9	8.2	9.5
6	1	7.9	9.2	10.1	9.9	8.1	7.8	9.5
6	2	8.2	10.3	10.1	9.9	8.4	7.9	9.8
6	3	8.6	11.4	10.1	8.1	8.4	7.9	9.8
6	4	8.7	12.2	10.8	8.5	8.4	7.9	9.8
6	5	8.4	11.4	8.5	9.6	8.4	8.4	9.0
7	0	7.5	10.1	9.6	9.8	8.0	8.2	8.8
7	1	7.5	9.7	9.5	10.0	8.3	7.8	9.3
7	2	7.8	10.4	9.7	10.2	8.5	7.9	9.6
7	3	7.9	11.5	9.9	9.1	8.5	7.9	9.8
7	4	8.2	12.2	10.3	8.5	8.5	8.0	9.8
7	5	8.4	12.6	10.6	10.7	8.5	7.9	9.8
7	6	8.2	13.2	10.7	8.0	8.5	8.0	9.8
7	7		12.4	11.0			8.0	
8	0	7.0	9.8	10.0	9.5	7.9	7.9	8.6
8	1	7.0	9.2	10.1	9.6	8.0	7.9	9.0
8	2	7.4	9.5	10.3	9.8	8.1	7.8	9.3
8	3	7.4	11.1	10.5	9.8	8.2	7.6	9.8
8	4	7.7	11.9	10.8	9.7	8.0	7.4	9.3
8	5		13.7	7.1		7.5	7.5	
8	6		12.4					
8	7		11.7					
9	0	7.0	9.6	9.5	9.5	7.8	7.6	8.7
9	1	7.0	8.9	9.4	9.6	8.0	7.3	9.1
9	2	7.0	9.7	9.7	9.7	8.2	7.2	9.5
9	3		10.9	10.1	9.6	8.3	7.5	9.4
9	4		11.7	10.3		8.3	7.7	9.6
9	5		12.4	10.6		8.0	7.6	10.7
9	6		13.2	10.9			7.6	
9	7		14.2				7.6	
9	8		14.4					
10	0	6.6	9.7	10.2	9.6	7.8	8.0	7.3
10	1	6.6	9.0	9.8	9.7	8.0	7.7	8.0
10	2	6.7	9.6	10.0	9.7	8.3	7.6	8.7
10	3	6.7	10.6	10.3	9.8	8.3	7.5	9.2
10	4		11.5	10.5	9.8	8.4	7.8	9.7
10	5		12.3	10.7	10.1	8.5	7.7	9.9
10	6		12.7	10.9	10.2	8.6	7.8	
10	7		13.0	11.1	10.2	8.6	8.0	
10	8		13.3	11.4	10.6			
10	9				10.5			

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	11.0	15.8	12.7	11.6	10.9	8.4	12.0
minimum	5.0	8.2	6.0	6.0	5.2	5.9	4.0
stan.dev.	1.0	1.8	1.0	1.3	1.7	0.6	1.2
average	8.2	11.0	10.2	9.7	8.0	7.5	9.0
skewness	+	-	+	+	+	-	-

A.2.2. MONTHLY FIELD AVERAGES OF DISSOLVED OXYGEN (mg/L), DUFFUS STREET, FEBRUARY-AUGUST, 1985

STATION	DEPTH (m)	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
1	0	9.5	10.7	9.5	10.6	7.2	6.0	7.1
2	0	10.0	9.5	9.9	11.2	7.8	5.9	9.4
2	1	9.8	10.5	10.6	11.4	8.0	6.4	10.0
2	2	10.0	11.7	11.2	11.7	8.4	6.6	10.8
2	3	10.0	12.6	11.5	12.1	8.8	6.7	11.2
2	4	10.2	13.3	12.1	12.3	9.1	6.8	11.6
2	5	10.5	13.7	12.5	12.5	9.3	6.9	11.6
2	6	10.4	14.1	12.7	12.7	9.4	7.0	11.5
2	7	10.5	14.1	12.9	12.7	9.4	6.9	11.5
2	8		14.9	13.1	12.7	9.6	6.9	10.9
2	9		14.6	13.2	12.7	9.6	6.8	11.0
2	10		14.6	13.2	12.7	10.0	6.8	12.3
3	0	9.6	10.6	10.8	11.2	8.5	6.6	8.5
3	1	9.5	9.8	10.8	11.3	8.5	6.7	9.2
3	2	9.6	10.8	11.2	11.5	8.5	6.8	9.9
3	3	9.8	11.7	11.6	11.8	8.7	6.8	10.4
3	4	9.8	12.7	11.9	12.0	8.9	7.0	10.9
3	5	10.0	13.0	12.3	12.1	9.1	7.1	11.0
3	6	10.7	13.6	12.5	12.5	9.2	7.1	11.3
3	7	10.3	14.1	12.7	12.5	9.3	7.0	11.5
3	8	10.3	14.3	12.8	12.5	9.4	7.0	11.7
3	9	10.4	14.4	12.9	12.5	9.5	7.0	11.7

cont'd

3	10	10.4	14.6	13.0	12.5	9.5	7.0	11.7
4	0	9.8	10.8	10.6	10.9	8.3	6.7	8.8
4	1	9.5	9.9	10.6	11.1	8.5	6.8	8.9
4	2	9.5	10.7	10.8	11.4	8.7	6.8	9.3
4	3	9.4	11.5	11.2	11.5	8.7	7.0	9.9
4	4	9.7	12.3	11.6	11.8	8.9	7.0	10.1
4	5	9.8	12.9	11.7	11.9	9.0	7.2	10.4
4	6	10.0	13.7	12.0	12.0	9.1	7.1	10.6
4	7	10.2	13.9	12.2	12.1	9.2	7.1	10.7
4	8	10.2	14.1	12.3	12.2	9.2	7.0	10.8
4	9	10.3	14.7	12.4	12.2	9.3	7.0	10.9
4	10	10.2	14.8	12.5	12.2	9.4	7.0	10.6
5	0	9.3	10.6	10.0	10.8	7.6	6.5	7.7
5	1	9.0	9.9	10.0	10.8	7.9	6.5	8.0
5	2	9.2	10.4	10.4	11.3	8.0	6.5	8.4
5	3	9.4	11.3	10.7	11.6	8.3	6.7	9.3
5	4	9.6	12.1	11.1	11.8	8.4	6.8	9.9
5	5	9.8	12.7	11.4	12.0	8.6	6.9	10.2
5	6	10.0	13.1	11.6	12.2	8.7	7.0	10.4
5	7	10.0	13.3	11.9	12.3	8.7	7.0	10.5
5	8		13.5	12.0	12.3	8.9	6.9	10.6
5	9		13.8	12.5	12.3	9.0	6.9	10.6
5	10			12.6	12.3	9.1	7.1	10.0
6	0	9.7	11.2	10.3	11.0	8.0	6.6	8.5
6	1	9.9	10.2	10.1	11.2	8.1	6.7	8.3
6	2	9.2	9.8	10.4	11.4	8.3	6.7	8.6
6	3	9.3	10.8	10.7	11.7	8.4	6.8	9.2
6	4	9.6	11.8	11.1	11.9	8.5	6.8	9.3
6	5	9.7	12.6	11.3	12.0	8.6	6.9	9.9
6	6	9.8	13.2	11.5	12.0	8.7	6.9	10.1
6	7	10.0	13.3	11.6	12.1	8.8	7.0	10.1
6	8	10.2	13.8	11.8	12.2	8.9	6.8	10.1
6	9	10.2	14.0	12.2	12.3	9.0	6.8	10.0
6	10	10.3	14.1	12.2	12.3	9.1	6.8	9.6
7	0	9.8	11.3	10.2	11.3	8.4	6.6	8.4

cont'd

7	9.0	10.4	9.9	11.3	8.4	6.6	8.4
7	9.0	10.9	10.1	11.4	8.6	6.7	8.5
7	9.0	11.4	10.5	11.6	8.6	6.8	9.0
7	9.3	11.9	10.7	11.8	8.7	6.9	9.2
7	9.5	12.4	10.9	11.9	8.8	6.9	9.5
7	9.6	12.8	11.0	12.0	8.8	6.9	9.8
7	9.8	12.8	11.3	12.0	8.9	6.8	9.8
7	9.8	13.2	11.4	12.1	8.9	6.9	9.9
7	10.0	13.3	11.4	12.1	9.2	6.9	9.9
7	10.0	13.9	10.3	12.0	9.0	6.0	9.9
8	9.1	11.3	9.8	10.8	8.0	6.4	7.9
8	8.4	10.4	9.5	10.8	8.0	6.5	8.1
8	8.4	10.5	9.8	11.2	8.2	6.5	8.4
8	8.8	11.1	10.1	11.3	8.3	6.7	8.8
8	9.0	11.6	10.3	11.5	8.4	6.8	9.1
8	9.3	12.1	10.7	11.6	8.6	6.9	9.3
8	9.4	13.1	10.9	11.8	8.6	6.9	9.3
8	9.6	13.4	11.0	11.9	8.7	6.8	9.6
8	9.6	13.3	11.1	11.9	8.9	6.7	9.7
8	9.8	14.2	11.3	12.0	8.9	6.7	9.6
8	9.8	14.6	11.4	12.0	8.0	6.4	7.9
9	9.5	12.1	9.8	10.7	8.0	6.6	7.9
9	8.6	10.2	9.6	10.7	8.0	6.6	7.9
9	8.6	10.0	9.6	11.1	8.2	6.4	8.3
9	8.8	10.6	9.9	11.3	8.3	6.8	8.8
9	8.8	11.4	10.2	11.5	8.4	6.9	9.1
9	9.0	12.6	10.4	11.6	8.5	6.9	9.2
9	9.1	13.1	10.7	11.7	8.6	7.0	9.2
9	9.2	13.6	10.8	11.8	8.6	6.9	9.3
9	9.4	13.7	10.9	11.9	8.7	6.9	9.4
9	9.6	14.1	11.0	11.9	8.7	6.8	9.4
9	9.7	14.5	11.1	12.0	8.9	6.7	9.3
10	9.1	11.7	9.7	10.8	8.0	6.5	8.4
10	8.3	10.7	9.4	11.0	8.2	6.6	8.4
10	8.3	10.4	9.6	11.2	8.2	6.7	8.5
10	8.4	10.6	9.9	11.3	8.4	6.8	8.8
10	8.7	11.1	10.1	11.5	8.4	6.9	8.9
10	8.8	11.7	10.4	11.6	8.5	6.9	9.1
10	9.0	12.7	10.6	11.7	8.6	6.9	9.2
10	9.2	13.1	10.8	11.7	8.7	6.9	9.2
10	9.3	13.8	10.9	11.8	8.7	6.8	9.1
10	9.3	13.7	11.0	11.9	8.7	6.8	9.3
10	9.3	14.0	10.8	11.9	8.8	6.8	9.3

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum
minimum
stan.dev.
average
skewness

10.5	16.6	15.3	13.7	10.0	9.2	15.4
8.3	8.1	8.0	8.8	7.2	4.4	6.6
0.5	2.0	1.3	0.9	0.5	1.3	1.8
9.6	12.4	11.1	11.8	8.7	6.8	10.3
11	-	-	-	11	+	+

n = normal distribution

A.2.3. MONTHLY FIELD AVERAGES OF DISSOLVED OXYGEN (mg/l.), DARTMOUTH COVE, FEBRUARY-AUGUST, 1985

STATION	DEPTH (m)	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
1	0	9.8	11.1	10.4	9.8	7.5	7.3	10.0
2	0	9.1	10.0	9.9	9.8	6.6	7.3	9.4
2	1	9.4	10.7	10.1	10.2	7.1	7.7	10.0
2	2	10.0	12.0	10.8	10.7	7.8	7.9	9.6
2	3	10.2	12.9	11.1	10.9	8.0	7.7	9.8
2	4		13.5	11.4	10.9	8.1	7.4	8.0
2	5		15.3		11.9		7.5	
2	6						6.3	
3	0	8.9	11.6	9.9	9.9	6.8	6.9	10.0
3	1	9.1	10.9	9.7	10.1	7.2	7.5	10.8
3	2	9.3	12.5	10.4	10.5	7.9	7.8	10.6
3	3	9.7	13.1	10.8	10.9	8.1	8.1	10.8
3	4	10.0	14.1	11.3	11.0	8.0	8.3	9.8
3	5	10.2	13.8	11.7	10.9		8.1	9.0
3	6		14.7	11.8	10.1			6.0
4	0	8.8	11.3	10.0	9.7	7.1	7.5	10.7
5	0	8.7	10.7	10.0	10.0	7.2	7.0	10.1
5	1	8.7	10.6	9.6	10.4	7.4	7.4	9.8
5	2	9.2	12.3	10.0	10.6	7.8	7.8	11.2
5	3	9.7	13.3	10.6	11.0	8.1	8.0	11.4
5	4	10.0	13.8	11.2	11.3	8.1	8.1	11.3
5	5	10.3	15.0	11.5	11.3	8.1	8.2	10.6
5	6	10.4	13.2	11.2	11.3	8.1		8.0
5	7			10.9	11.2			
6	0	8.5	10.2	9.5	9.5	7.2	7.2	9.4
6	1	8.7	10.4	9.6	9.8	7.0	7.3	10.0
6	2	9.0	11.2	9.9	10.0	7.3	7.3	10.3
6	3	9.4	11.1	10.7	10.1	7.5	7.5	9.8
6	4	9.7	11.5	10.0	9.9	6.6	7.0	6.0
7	0	8.6	9.8	9.6	9.5	6.7	6.9	10.0
7	1	8.4	9.6	9.6	9.8	6.9	7.5	10.8
7	2	8.9	10.2	10.0	10.3	7.4	7.7	10.8
7	3	9.4	11.1	10.9	10.6	7.5	7.9	11.0
7	4	9.8	11.2	11.3	10.7	7.2	8.0	10.7
7	5	10.2	12.1	11.5	10.7		8.1	10.8
7	6	10.6	12.6	10.1	9.1	7.2	6.2	8.0

cont'd

8	9.1	10.7	9.7	9.5	6.5	6.8	9.6
8	8.5	10.1	9.4	9.8	6.7	7.4	10.4
8	8.9	10.9	9.6	10.1	7.3	7.7	10.8
8	9.4	12.1	9.9	10.4	7.5	7.8	10.8
8	9.7	13.1	10.2	10.6	7.6	7.9	10.8
8	10.2	13.4	10.5	10.6	7.3	8.0	11.0
8	10.2	12.3	10.7	10.4	7.3	8.0	10.4
8	10.2	12.6	10.7	11.5	6.3	6.3	6.0
9	8.9	10.2	9.9	9.4	6.4	7.2	9.2
9	8.4	9.3	9.5	9.7	7.0	7.6	11.0
9	8.8	10.0	9.6	10.0	7.4	7.8	11.0
9	9.2	11.0	9.8	10.4	7.6	7.8	10.4
9	9.6	12.0	10.0	10.6	7.8	7.9	10.2
9	10.1	13.1	10.5	10.7	7.7	8.0	10.4
9	10.5	13.4	10.7	10.6	6.9	7.9	10.8
9	8.6	13.9	10.8	11.4	7.6	7.6	8.0
9	7.0	14.5	10.3	9.8	6.5	7.4	9.4
10	8.4	12.5	9.5	10.0	6.9	7.1	11.0
10	7.9	10.7	9.6	10.3	7.4	7.7	11.2
10	8.1	11.3	10.3	10.5	7.5	7.8	11.4
10	8.3	12.1	10.7	10.7	7.7	7.9	11.0
10	8.8	13.1	10.6	10.7	7.7	8.0	11.1
10	9.0	14.0	10.6	10.7	7.9	8.0	11.1
10	9.2	14.1	10.6	10.6	8.0	7.7	10.4
10	9.1	14.9	11.2	10.6	8.0	7.7	6.0
10	9.7	15.0		10.2			
10	9.0	15.5					
10		15.0					

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	11.3	18.8	12.6	12.7	9.6	9.6	11.4
minimum	6.9	8.5	6.9	5.9	5.5	3.0	6.0
stan.dev.	0.9	2.2	1.0	1.3	0.9	1.3	1.4
average	9.2	12.3	10.4	10.3	7.3	7.5	10.0
skewness	-	+	n	-	+	+	-

n = normal distribution

A.2.4. MONTHLY FIELD AVERAGES OF DISSOLVED OXYGEN (mg/L), SACKVILLE STREET, FEBRUARY-AUGUST, 1985

STATION	DEPTH (m)	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
1	0	10.7	9.7	9.5	10.4	9.0	7.0	7.7
2	0	10.0	9.1	10.0	10.0	7.2	7.5	8.7
2	1	10.2	11.1	10.5	10.3	7.6	7.2	8.8
2	2	10.4	12.0	10.8	10.6	8.0	7.8	9.0
2	3	11.0	13.9	11.1	11.0	8.5	7.9	9.0
2	4	11.2	14.4	11.4	11.3	8.7	8.0	9.3
2	5	10.8	15.0	11.6	11.4	8.8	8.2	9.2
2	6	11.4	15.3	11.8	11.5	8.7	8.3	9.4
2	7	11.3	15.5	11.8	11.7	8.8	8.5	9.3
2	8	11.5	15.8	11.9	12.0	10.5	8.3	9.2
2	9	11.5	14.6	11.8	12.0	10.7	8.3	
2	10	11.8	13.6	11.4	12.0	10.7	8.1	
3	0	10.6	11.3	10.4	10.3	7.6	7.5	9.8
3	1	10.2	9.9	10.6	10.6	7.9	7.6	9.8
3	2	10.5	11.8	10.8	10.8	8.1	7.7	9.9
3	3	10.7	12.8	11.2	11.1	8.5	8.0	10.0
3	4	11.0	13.3	11.4	11.2	8.7	8.1	10.0
3	5	11.3	14.2	11.6	11.4	8.9	8.1	9.9
3	6	11.5	14.6	11.8	11.5	9.0	8.3	9.9
3	7	11.8	15.0	11.9	11.7	9.1	8.3	9.9
3	8	11.9	15.1	12.1	11.8	9.3	8.5	9.9

cont'd

3	9	12.0	15.1	12.2	11.9	9.4	8.6	9.9
3	10	12.7	15.1	12.2	11.9	9.5	8.6	9.8
4	0	11.0	11.3	10.4	10.5	8.1	7.6	10.0
4	1	10.2	10.5	10.5	10.6	8.0	7.7	10.1
4	2	10.2	11.2	10.8	10.9	8.4	7.8	10.5
4	3	10.3	12.1	11.0	11.0	8.4	8.0	10.7
4	4	10.8	13.4	11.3	11.2	8.6	8.1	10.6
4	5	11.1	13.6	11.5	11.4	8.5	8.2	10.6
4	6	11.4	14.2	11.7	11.5	8.9	8.3	10.4
4	7	11.7	14.5	11.8	11.6	9.0	8.4	10.2
4	8	11.9	14.0	12.0	11.6	9.1	8.5	10.0
4	9	12.3	14.9	12.1	11.7	9.2	8.5	9.8
4	10	12.3	15.1	12.1	11.8	9.2	8.7	9.8
5	0	10.4	11.6	11.2	10.2	7.6	7.2	9.4
5	1	9.5	10.5	10.5	10.4	7.7	7.2	9.3
5	2	9.5	11.6	10.8	10.6	8.0	7.4	9.4
5	3	9.8	12.5	11.0	10.8	8.3	7.6	9.4
5	4	10.6	13.5	11.2	10.9	8.5	7.6	9.6
5	5	10.9	14.1	11.5	11.1	8.8	7.9	9.7
5	6	11.2	14.6	11.7	11.3	8.9	8.0	9.6
5	7	11.5	14.8	11.8	11.5	9.0	8.1	9.5
5	8	11.7	15.1	11.9	11.6	9.2	8.1	9.6
5	9	12.0	15.2	12.0	11.6	9.3	8.2	9.7
5	10	12.2	14.8	12.0	11.6	9.3	8.3	9.5
6	0	10.0	11.6	10.1	10.3	7.5	7.4	8.9
6	1	9.4	10.5	10.2	10.3	7.7	7.4	9.0
6	2	9.3	11.7	10.5	10.6	7.9	7.5	9.5
6	3	9.8	12.6	10.8	10.7	8.2	7.6	9.8
6	4	10.0	13.5	11.0	10.9	8.4	7.5	9.9
6	5	10.6	14.5	11.2	11.0	8.6	8.0	9.8
6	6	11.0	15.0	11.4	11.1	8.7	8.0	9.8
6	7	11.4	14.8	11.5	11.3	8.8	8.1	9.7
6	8	11.6	15.4	11.7	11.4	9.0	8.2	9.7
6	9	11.8	16.0	11.8	11.5	9.0	8.2	9.6
6	10	11.9	16.0	11.8	11.6	9.1	8.2	9.7

cont'd

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	12.8	18.3	13.2	12.7	11.5	9.0	10.7
minimum	9.0	7.4	8.8	9.6	6.0	6.6	6.9
stan.dev.	0.9	2.4	1.0	0.8	1.4	0.5	0.6
average	10.9	13.5	11.3	11.1	8.7	8.0	9.6
skewness	n	n	+	+	-	+	n

n = normal distribution

A.2.5. MONTHLY FIELD AVERAGES OF DISSOLVED OXYGEN (mg/L), PIER A, FEBRUARY-AUGUST, 1985

STATION	DEPTH (m)	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
1	0	9.2	8.3	8.8	8.8	6.3	6.1	9.3
2	0	9.6	8.2	9.6	9.7	7.0	7.4	9.6
2	1	9.4	9.5	9.8	10.0	7.3	7.5	9.7
2	2	9.6	11.0	10.2	10.3	7.8	7.6	9.8
2	3	9.7	12.2	10.5	10.5	8.0	7.9	9.3
2	4	9.9	13.5	10.8	10.7	8.2	7.9	8.8
2	5	10.1	14.3	11.0	10.9	8.4	7.9	8.8
2	6	10.3	14.3	11.1	11.0	8.3	7.9	8.8
2	7	10.5	14.7	11.3	11.2	8.3	7.9	9.1
2	8	10.8	15.1	11.5	11.2	8.5	7.9	9.2
2	9	11.1	14.9	11.5	11.2	8.5	7.9	9.3
2	10	11.2	15.0	11.4	11.1	8.5	7.6	9.7
3	0	10.2	11.0	9.7	10.0	7.5	7.8	9.7
3	1	9.0	10.6	9.8	10.2	7.7	7.7	9.7
3	2	9.1	12.1	10.1	10.4	7.9	7.8	9.9
3	3	9.5	13.7	10.4	10.7	8.1	7.9	9.9
3	4	9.8	14.5	10.7	10.9	8.3	8.0	9.8
3	5	10.0	15.5	10.9	10.9	8.4	8.0	9.7
3	6	10.3	15.7	11.0	11.0	8.5	8.1	9.9
3	7	10.6	16.2	11.2	11.1	8.6	8.2	10.0
3	8	10.9	15.9	11.3	11.2	8.7	8.2	9.6
3	9	11.1	16.4	11.4	11.3	8.7	8.0	9.6
								cont'd

3	11.2	16.6	11.4	11.3	8.7	8.0	9.5
4	9.6	8.7	8.6	8.1	7.2	6.8	7.2
5	9.2	10.7	9.4	9.9	8.7	7.7	10.0
5	8.9	9.8	9.7	10.1	8.7	7.7	10.4
5	8.6	11.2	9.9	10.3	8.8	7.9	10.6
5	9.1	13.1	10.3	10.5	9.0	8.1	10.6
5	9.2	13.8	10.5	10.8	9.1	8.1	10.4
5	9.5	14.9	10.8	10.9	9.3	8.2	10.3
5	9.7	15.1	10.9	11.0	9.2	8.2	10.2
5	10.1	15.3	11.1	11.1	9.2	8.3	10.1
5	10.2	15.9	11.3	11.3	9.3	8.2	9.8
5	10.7	16.1	11.4	11.3	9.4	8.3	9.6
5	10.7	16.1	11.5	11.3	9.4	8.5	9.4
6	10.1	11.8	9.7	10.2	8.8	7.8	10.0
6	9.5	10.7	9.7	10.4	8.8	7.9	10.4
6	8.5	12.2	9.8	10.5	8.9	8.0	10.6
6	9.1	13.3	10.1	10.6	9.0	8.0	10.6
6	9.1	14.3	10.3	10.8	9.1	8.0	10.4
6	9.1	15.3	10.6	10.9	9.1	8.0	10.3
6	9.6	15.4	10.8	11.0	9.1	8.1	10.2
6	9.8	16.0	11.0	11.1	9.2	8.1	10.1
6	10.3	15.4	11.2	11.1	9.2	8.2	9.8
6	10.4	16.5	11.3	11.2	9.3	8.3	9.6
6	10.6	16.6	11.2	11.2	9.2	8.3	9.4

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	11.3	18.6	12.3	11.8	10.5	9.1	10.6
minimum	8.5	7.2	7.8	6.7	6.0	2.4	7.2
stan.dev.	0.7	2.9	1.0	0.8	1.1	0.8	0.7
average	9.9	13.7	10.6	10.7	8.2	7.8	9.7
skewness	+	n	+	n	n	+	+

n = normal distribution

A.3.1. MONTHLY FIELD AVERAGES OF SALINITY (o/oo), TUFTS COVE, FEBRUARY-AUGUST, 1985

STATION	DEPTH	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
(m)								
1	0	27.5	29.0	32.1	26.3	21.1	24.0	28.3
2	0	28.2	28.5	32.3	31.2	26.1	27.3	26.5
2	1	28.0	27.8	32.4	31.9	27.3	29.5	27.3
2	2	26.5	25.6	29.1	32.3	27.8	31.6	27.8
2	3		26.0	33.9		27.5	32.0	29.9
2	4						29.2	30.0
3	0	27.6	29.9	31.9	31.0	26.2	24.1	25.8
3	1	28.3	30.1	32.3	31.3	27.7	26.5	26.6
3	2	28.4	30.0	32.4	31.9	28.5	30.1	27.0
3	3	28.4	27.0	32.6	31.4	28.6	29.6	27.2
3	4		25.0	33.0			30.4	29.0
4	0	27.5	29.1	31.7	30.9	26.0	24.6	26.0
4	1	28.3	29.0	32.7	31.4	27.5	26.8	26.7
4	2	28.7	29.0	32.5	32.2	28.4	29.0	26.8
4	3	28.7	29.0	33.0	32.0	28.6	29.3	27.3
4	4	27.5	29.5	33.5	31.6	28.7		29.5
4	5					31.3		
5	0	28.0	30.0	31.7	31.4	27.0	25.0	26.6
5	1	28.5	28.4	31.8	31.8	27.6	25.6	26.7
5	2	29.0	28.4	31.9	32.1	28.2	29.0	27.2
5	3	29.0	28.0	31.7	31.7	28.7	29.7	27.2
5	4	28.5	29.0	33.0	30.2	29.0		
5	5	27.3	28.9	32.3			29.8	

cont'd

6	28.7	27.4	31.3	26.5	25.0	26.5
6	28.7	27.9	31.7	27.5	25.5	27.3
6	29.0	27.7	31.8	28.2	29.0	27.3
6	28.7	27.3	32.0	28.7	30.0	27.5
6	28.3	27.1	31.9	28.9	30.4	26.6
6	27.0	29.1	32.7			
6	29.5	28.5	31.3	26.3	26.1	27.0
7	29.5	28.7	31.8	26.8	26.0	27.7
7	29.2	28.8	33.0	27.6	26.2	27.6
7	29.1	28.8	32.2	28.2	29.0	27.4
7	28.8	27.2	31.8	28.7	31.1	26.6
7	28.8	28.1	33.9		31.0	
7	26.0	28.2	33.5	28.8	31.2	
7	25.5	28.7	33.5			
7	29.0	29.7	31.8	26.2	26.0	25.9
8	29.0	29.7	31.8	27.3	26.0	26.9
8	30.0	29.5	32.2	28.3	28.0	27.1
8	30.1	29.5	32.0	28.6	29.0	27.2
8	29.2	29.4	32.8	29.2	31.0	27.1
8		28.5	31.5	29.3	30.7	
9	29.0	28.6	31.4	26.6	26.8	26.9
9	29.1	28.4	32.9	27.0	27.3	26.7
9	29.1	28.5	32.0	28.4	28.0	26.9
9		28.5	32.9	28.8	29.0	27.3
9		28.6	32.8	28.9	31.5	27.4
9		28.3	32.8	28.9	31.8	25.6
9		28.4	32.9		31.0	
10	29.0	28.4	31.5	26.7	26.0	27.0
10	29.0	28.3	31.6	27.5	26.8	27.2
10	29.7	28.6	31.7	28.6	27.5	27.3
10		28.4	32.6	29.0	29.0	26.8
10	29.8	28.5	32.6	28.7	30.0	26.9
10		28.6	32.6	28.9	30.2	27.6
10		29.0	32.6	29.2	30.9	
10			32.2	29.5	31.0	
10			32.8			
10			32.8			

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	32.0	30.5	35.0	33.1	31.0	33.0
minimum	25.5	13.0	19.0	21.0	20.5	22.0
stan.dev.	1.4	3.7	1.6	1.7	1.5	2.6
average	28.5	27.0	32.4	31.6	28.5	27.2
skewness	-	-	+	-	-	-
n					n	

n = normal distribution

A.3.2. MONTHLY FIELD AVERAGES OF SALINITY (o/oo), DUFFUS STREET, FEBRUARY-AUGUST, 1985

STATION	DEPTH (m)	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
1	0	25.5	24.7	21.7	19.7	18.0	18.9	20.3
2	0	29.7	31.3	29.8	28.8	28.0	23.9	26.2
2	1	30.0	31.8	33.2	32.0	29.0	28.7	27.0
2	2	30.0	30.9	33.3	31.8	29.0	29.9	26.8
2	3	30.0	30.9	33.6	32.0	29.5	30.4	27.1
2	4	30.0	31.0	33.6	32.1	29.5	31.0	27.1
2	5	30.0	31.4	33.7	32.5	29.5	30.7	27.0
2	6	30.1	31.2	33.7	32.5	29.5	31.7	27.3
2	7	30.2	31.4	33.6	32.5	29.5	31.9	26.8
2	8		31.4	33.5	32.5	30.0	31.7	27.0
2	9		31.5	33.5	32.7	30.0	32.1	26.8
2	10		31.4	33.5	32.9	30.1	32.4	26.8
3	0	29.8	30.0	32.0	29.3	28.9	27.7	24.3
3	1	29.9	30.4	32.7	31.3	28.8	28.1	25.8
3	2	29.9	30.5	33.3	31.4	28.5	30.1	26.3
3	3	29.9	30.5	33.2	31.8	30.9	30.9	25.5
3	4	29.9	30.6	33.6	32.0	29.1	30.8	26.3
3	5	29.9	30.7	33.6	32.1	29.1	31.0	26.0
3	6	30.0	30.9	33.5	32.5	29.5	31.9	27.0
3	7	30.0	30.9	33.5	33.0	29.9	32.0	27.0
3	8	30.0	31.0	33.7	33.2	30.0	32.3	27.0
3	9	30.1	31.0	33.7	33.1	30.1	32.3	27.3
3	10	30.1	31.0	33.7	32.9	30.5	32.3	27.1
4	0	29.1	30.5	32.4	29.6	27.7	28.1	24.5

cont'd

4	1	29.4	30.6	32.7	30.9	28.5	28.7	25.5
4	2	29.5	30.8	33.0	31.2	29.0	29.2	25.5
4	3	29.9	30.8	33.4	31.6	29.0	30.5	26.3
4	4	30.0	30.9	33.4	32.3	29.2	31.0	26.5
4	5	30.0	30.9	33.4	32.3	29.5	31.9	26.5
4	6	30.0	31.0	33.4	32.4	29.5	32.1	26.5
4	7	30.0	31.1	33.4	32.5	29.5	32.2	26.5
4	8	30.0	31.1	33.4	32.9	29.9	32.3	26.5
4	9	30.0	31.1	33.3	33.1	29.8	32.3	26.5
4	10	30.0	31.1	33.3	33.1	30.1	32.4	26.1
5	0	28.5	29.5	29.7	28.9	26.2	27.9	23.3
5	1	29.0	30.2	31.9	30.7	29.2	28.3	24.5
5	2	29.7	30.4	32.2	31.1	29.2	29.0	24.4
5	3	29.8	30.4	32.4	31.4	29.4	30.4	25.8
5	4	29.8	30.5	32.4	31.9	29.4	30.9	26.3
5	5	29.8	30.7	32.6	32.1	29.4	31.5	25.0
5	6	29.9	30.9	33.0	32.4	29.5	31.8	25.8
5	7	29.9	31.0	33.0	32.6	29.6	32.2	25.3
5	8	30.0	31.0	33.0	32.6	30.1	32.3	25.3
5	9			32.4	32.6	30.9	32.3	26.0
5	10			33.5	32.6	31.1	31.5	24.8
6	0	28.5	30.6	32.8	30.3	27.9	27.4	24.6
6	1	29.0	30.5	33.1	30.4	29.0	28.5	25.3
6	2	29.1	30.7	32.8	30.7	29.2	30.2	25.8
6	3	29.6	30.7	32.8	31.0	29.3	30.8	25.8
6	4	29.8	30.7	33.1	31.4	29.7	31.2	25.9
6	5	30.0	30.8	33.2	31.1	29.5	31.8	26.0
6	6	30.0	30.9	33.3	31.3	29.6	31.5	26.0
6	7	30.0	30.9	33.3	31.6	29.9	32.0	26.1
6	8	30.0	30.9	33.3	32.0	30.5	32.2	26.3
6	9	30.0	30.9	33.0	31.8	30.6	32.2	26.3
6	10	30.0	30.9	33.0	31.4	31.0	32.4	26.3
7	0	28.6	29.7	32.5	29.6	27.0	27.8	24.8
7	1	29.1	30.0	32.5	30.9	28.5	28.7	24.8
7	2	29.3	30.2	32.7	31.0	29.4	29.4	25.3
7	3	29.8	30.3	32.9	31.4	29.4	30.3	25.8
7	4	29.9	30.4	33.2	31.8	29.4	30.6	25.8

cont'd

7	5	29.9	30.5	33.2	32.8	29.7	31.7	25.8
7	6	30.0	30.5	33.3	32.4	29.7	31.7	26.0
7	7	30.0	30.5	33.2	32.6	29.6	32.2	26.0
7	8	30.0	30.5	33.3	32.7	30.4	32.2	26.1
7	9	30.0	30.5	33.3	32.7	31.2	32.4	26.2
7	10	30.0	31.9	32.5	32.6	32.4	33.3	26.1
8	0	27.2	29.5	30.6	29.5	27.0	28.5	23.8
8	1	29.0	29.9	31.6	31.0	28.5	28.6	24.9
8	2	29.1	30.0	32.7	31.6	29.4	29.1	25.4
8	3	29.2	30.1	33.0	31.7	29.4	30.5	25.7
8	4	29.5	30.1	33.0	31.8	29.4	31.1	26.0
8	5	29.6	30.2	33.0	32.2	29.7	31.7	26.0
8	6	29.6	30.4	33.2	32.5	29.7	32.2	26.0
8	7	29.6	30.4	33.2	32.5	29.6	32.3	26.1
8	8	29.7	30.5	33.3	32.5	30.4	32.6	26.1
8	9	29.9	30.5	33.3	32.4	31.2	32.4	26.1
8	10	29.9	30.5	33.1	32.6	32.4	32.5	26.2
9	0	29.1	29.1	31.8	29.1	27.9	27.9	24.3
9	1	29.7	29.7	32.1	31.0	28.2	28.3	25.3
9	2	30.2	30.2	32.7	31.6	29.1	29.8	25.3
9	3	30.3	30.3	33.1	31.8	29.1	30.6	26.2
9	4	30.3	30.3	33.1	32.0	29.5	30.8	25.8
9	5	30.3	30.3	33.2	32.3	29.5	31.5	26.8
9	6	30.4	30.4	33.2	32.7	29.4	32.0	27.3
9	7	30.4	30.4	33.2	32.4	29.6	32.1	27.3
9	8	29.2	30.4	33.2	32.6	30.0	32.3	27.3
9	9	29.2	30.4	33.2	32.6	30.0	32.3	27.4
9	10	28.3	30.4	33.2	32.5	30.8	32.4	27.5
10	0	28.8	29.7	31.8	30.6	28.6	27.4	25.8
10	1	29.0	29.9	32.3	31.1	28.3	28.0	26.0
10	2	29.0	29.9	32.6	31.3	28.6	29.0	26.3
10	3	29.0	30.1	33.0	31.9	29.0	30.3	26.4
10	4	29.0	30.2	33.1	32.1	29.3	31.0	26.2
10	5	29.0	30.6	33.1	32.3	29.4	31.4	26.3
10	6	29.0	30.6	33.1	32.4	29.8	31.8	25.8
10	7	29.2	30.7	33.1	32.5	30.0	32.2	26.0
10	8	29.2	30.7	33.4	32.6	30.0	32.3	26.3
10	9	29.2	30.7	33.1	32.5	29.1	32.3	26.8
10	10	29.2	30.7	33.1	32.7	31.0	32.3	26.8

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	30.2	34.8	34.6	32.4	34.5	30.5
minimum	25.5	20.0	10.0	18.0	18.0	18.5
stan. dev.	0.7	1.7	2.0	1.4	2.4	3.6
average	29.5	32.8	31.7	29.4	20.7	26.0
skewness	-	n	-	n	-	+

is normal distribution

A.3.3. MONTHLY FIELD AVERAGES OF SALINITY (o/oo), DARTMOUTH COVE, FEBRUARY-AUGUST, 1985

STATION	DEPTH (m)	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
1	0	25.0	22.0	28.9	23.1	21.3	31.0	28.1
2	0	27.8	26.4	30.3	24.3	21.3	25.5	28.0
2	1	29.8	30.1	31.7	30.5	24.7	27.8	29.5
2	2	30.0	31.1	32.7	31.5	28.6	28.5	31.5
2	3	30.0	31.4	32.7	32.3	29.5	29.5	31.0
2	4		31.4	32.7	32.5	28.8	30.0	31.0
2	5		31.1	34.0			29.8	
2	6						30.0	
3	0	27.6	28.5	30.8	25.2	22.1	24.0	28.6
3	1	28.4	30.0	32.6	30.3	27.0	28.0	29.9
3	2	29.9	31.2	33.0	32.3	28.5	29.3	30.5
3	3	29.9	31.1	33.0	32.6	28.5	28.3	30.8
3	4	30.0	31.4	33.0	33.0	28.9	29.8	30.8
3	5	31.0	31.3	33.0	33.0		30.3	31.3
3	6		31.3	33.0				31.0
4	0	25.0	26.5	27.7	23.4	19.3	24.5	28.1
4	1	27.2	29.0	31.4	29.3	22.5	23.5	28.8
5	0	28.2	30.2	32.5	31.7	27.0	28.3	29.0
5	2	29.2	30.2	32.6	31.8	28.5	29.0	30.6
5	3	29.9	31.0	32.7	32.8	28.6	31.3	31.0
5	4	30.0	31.1	32.8	33.0	28.7	31.0	31.0
5	5	30.0	31.1	32.9	33.2	28.7	31.0	31.0
5	6	30.0	31.2	32.9	33.2	29.0	31.3	31.0
5	7			33.1	34.2			
6	0	25.8	28.4	28.2	25.2	22.9	26.5	27.0
6	1	29.2	30.0	32.3	30.6	26.0	30.5	28.8
6	2	29.5	30.7	32.2	31.9	28.8	30.5	31.0
6	3	29.8	31.0	32.5	32.6	29.1	31.3	31.0
6	4	29.7	31.2	31.9	33.1	25.9	31.5	30.7
7	0	26.4	27.4	28.5	26.3	21.2	27.5	29.0
7	1	28.6	30.2	32.0	29.9	27.0	29.5	29.5
7	2	28.9	30.7	32.2	32.5	28.7	30.5	29.8
7	3	29.6	30.9	32.3	32.7	29.1	30.8	30.3
7	4	29.7	31.0	32.3	33.0	29.3	30.8	31.0
7	5	30.5	31.0	32.3	33.3	21.0	31.0	31.4
7	6	30.4	31.1	31.8	33.0		31.5	31.0

cont'd

8	28.5	29.7	31.3	25.4	21.4	25.3	27.0
8	28.7	29.9	31.8	31.5	27.3	29.5	28.9
8	29.4	30.7	31.9	32.2	28.8	31.3	29.0
8	29.5	30.9	32.3	33.1	29.2	31.3	30.8
8	29.5	31.0	32.3	33.0	29.3	32.0	31.0
8	29.7	31.0	32.3	33.3	29.3	32.0	31.0
8	30.2	30.1	32.3	33.4	29.3	32.3	31.0
8		30.3			34.0	32.0	31.2
9	28.2	25.8	30.3	26.5	21.2	28.0	30.5
9	29.3	29.7	31.6	32.0	26.2	29.5	31.0
9	29.3	30.2	32.1	32.7	28.7	31.0	30.0
9	29.4	30.8	32.2	33.1	29.2	31.3	30.8
9	29.4	30.8	32.3	33.0	29.2	31.3	31.0
9	29.4	30.9	32.3	33.3	29.2	32.3	31.0
9	29.6	31.1	32.3	33.3	29.4	31.8	31.0
9	29.5	30.9	32.3	34.8		32.3	31.0
9	29.0	31.0				32.3	
9						32.3	
10	27.0	27.8	31.5	27.1	22.3	26.5	28.5
10	28.0	29.8	31.8	32.3	27.5	29.0	29.5
10	29.3	30.4	31.8	32.7	28.7	30.5	29.5
10	29.1	30.4	32.0	33.1	28.9	31.5	30.2
10	29.4	30.8	32.2	33.2	29.0	31.6	30.0
10	29.4	30.8	32.2	33.1	28.8	31.5	30.9
10	29.4	30.9	32.2	33.7	29.5	31.8	30.9
10	29.4	30.9	32.2	33.4	29.4	31.5	31.2
10	29.5	31.0					
10	29.0	30.9					
10		31.1					

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	31.0	32.5	34.0	37.0	30.2	34.5	31.4
minimum	21.0	15.0	24.0	19.0	13.0	19.5	27.0
stan.dev.	1.9	2.3	1.5	3.7	3.5	2.7	1.1
average	29.0	30.2	31.9	31.5	27.0	29.9	30.2
skewness	+		+	-		+	-

3	10	32.6	33.0	32.6	32.6	31.5	30.3
4	0	31.3	32.4	30.6	28.8	31.5	29.0
4	1	31.0	32.9	31.2	29.0	28.2	28.7
4	2	31.1	32.9	31.3	29.2	28.3	28.3
4	3	31.1	32.9	31.7	29.2	28.6	29.2
4	4	31.2	32.9	32.1	29.3	29.6	29.0
4	5	31.0	32.9	32.0	29.4	30.3	29.1
4	6	28.7	32.9	32.3	29.4	30.8	29.2
4	7	31.5	32.9	32.4	29.5	30.8	29.8
4	8	31.7	32.9	32.4	29.5	31.1	29.9
4	9	31.9	32.9	32.6	29.4	31.1	29.8
4	10	32.0	32.8	32.6	29.4	31.4	29.8
5	0	30.8	32.8	30.3	28.9	31.6	30.0
5	1	31.0	32.8	31.4	29.0	27.9	29.3
5	2	30.5	32.8	31.6	29.3	28.0	28.3
5	3	31.0	32.8	31.6	29.3	29.6	28.9
5	4	31.1	32.8	31.7	29.6	30.0	29.2
5	5	31.0	32.8	32.2	29.6	30.8	29.8
5	6	31.1	32.9	32.1	29.6	30.8	29.8
5	7	31.0	32.9	32.3	29.6	31.3	29.9
5	8	31.3	32.9	32.3	29.6	31.4	30.1
5	9	31.4	32.8	32.5	29.6	31.7	30.1
5	10	31.9	32.8	32.5	29.5	31.8	30.1
6	0	31.0	33.0	31.0	29.5	32.0	30.2
6	1	30.9	33.2	31.2	29.3	28.0	28.3
6	2	31.0	33.1	31.6	29.3	28.3	29.0
6	3	31.0	33.2	31.9	29.3	28.7	29.3
6	4	31.1	33.2	32.0	29.3	29.3	29.3
6	5	31.0	33.2	32.1	29.3	29.3	29.3
6	6	31.2	33.2	31.9	29.3	31.3	29.8
6	7	31.2	33.2	32.2	29.4	31.3	29.8
6	8	31.6	33.2	32.3	29.5	31.5	30.1
6	9	31.6	33.2	32.4	29.4	31.6	30.2
6	10	31.8	33.2	32.3	29.5	31.8	30.5

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	29.6	35.0	33.8	33.1	35.0	32.4	31.0
minimum	24.0	20.5	28.0	25.0	17.0	24.5	25.5
stan.dev.	0.6	2.5	0.7	1.3	2.4	1.6	0.8
average	29.2	31.3	32.9	31.8	28.2	30.1	29.5
skewness		-		n	+	-	n

n = normal distribution

A.3.5. MONTHLY FIELD AVERAGES OF SALINITY (o/oo), PIER A, FEBRUARY-AUGUST, 1985

STATION (m)	DEPTH	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
1	0	27.9	26.0	23.8	25.1	18.3	20.6	27.0
2	0	28.8	29.6	32.4	29.6	23.0	28.3	28.3
2	1	29.0	30.0	32.9	31.0	24.7	28.5	28.5
2	2	29.2	29.9	33.0	31.2	27.1	28.8	28.9
2	3	29.2	30.2	33.2	31.0	27.4	30.3	29.0
2	4	29.3	30.1	33.2	31.0	28.0	31.8	29.2
2	5	29.3	30.3	33.2	31.8	28.3	31.3	29.8
2	6	29.3	30.3	33.1	32.1	28.5	31.1	30.0
2	7	29.3	30.3	33.1	32.4	28.8	31.7	30.1
2	8	29.3	30.3	33.1	32.3	28.8	31.9	30.5
2	9	29.3	30.4	33.0	32.4	29.0	32.1	30.2
2	10	29.3	30.4	33.0	32.5	29.0	32.3	30.5
3	0	28.6	29.4	33.0	30.4	24.6	28.2	28.5
3	1	29.1	29.5	33.1	30.9	26.8	30.3	28.5
3	2	29.2	29.6	33.4	31.5	27.1	30.3	29.0
3	3	29.3	30.1	33.0	31.7	26.9	30.3	29.0
3	4	29.3	30.0	33.1	31.9	27.6	30.5	29.5
3	5	29.3	30.0	33.1	31.9	27.2	30.8	29.9
3	6	29.3	30.0	33.0	32.4	27.5	31.1	30.1
3	7	29.3	30.3	33.3	32.1	28.1	31.3	30.0
3	8	29.3	30.2	33.0	32.1	28.7	31.7	
3	9	29.3	30.0	33.0	32.3	28.9	31.7	

cont'd

3	10	29.3	30.0	33.0	32.4	28.9	31.8	20.0
4	0	26.0	26.8	22.0	22.2	23.5	24.5	28.3
5	0	28.5	29.6	33.0	30.7	26.3	29.5	28.9
5	1	29.0	29.6	33.0	31.0	26.4	29.8	29.1
5	2	29.1	30.1	33.0	31.3	26.5	30.3	29.5
5	3	29.1	30.0	33.0	31.5	27.1	30.5	30.1
5	4	29.3	30.1	32.9	31.2	28.0	31.0	30.5
5	5	29.3	30.1	33.0	32.0	28.0	31.5	30.5
5	6	29.3	30.1	33.0	32.3	28.3	31.8	30.5
5	7	29.3	30.1	33.0	32.3	28.3	32.0	30.6
5	8	29.3	30.3	33.0	32.4	28.4	32.0	31.0
5	9	29.3	30.5	32.9	32.4	28.7	32.0	31.0
5	10	29.3	30.1	32.9	32.6	28.5	32.0	28.5
6	0	27.5	29.3	33.1	30.5	26.4	28.7	29.9
6	1	28.6	29.5	33.0	31.1	27.0	29.0	29.9
6	2	28.8	29.5	33.0	31.3	26.9	30.3	29.3
6	3	28.7	29.6	33.1	31.6	27.8	30.6	29.3
6	4	28.8	29.8	33.0	31.5	28.0	30.8	30.1
6	5	29.0	29.8	33.0	31.3	28.3	31.0	30.0
6	6	29.0	29.8	32.9	32.0	28.3	31.3	30.5
6	7	29.0	29.8	32.9	32.0	28.2	31.6	30.0
6	8	29.0	29.9	32.9	32.1	28.4	31.9	30.0
6	9	29.0	30.1	32.9	32.3	28.3	32.0	31.0
6	10	29.0	30.4	32.9	32.5	28.7	32.0	30.5

STATISTICAL ANALYSIS OF THE DAILY DATA

max imum	29.5	33.0	33.9	33.0	29.9	32.5	31.0
minimum	26.0	21.0	18.0	15.0	16.0	15.0	20.0
stan. dev.	0.6	2.3	2.2	2.3	2.4	2.3	1.7
average	29.0	29.9	32.6	31.4	27.2	30.5	29.5
skewness	+	-			+	-	n

n = normal distribution

A.4.1. MONTHLY FIELD AVERAGES OF CONDUCTIVITY (100 x μ S/cm), TUFTS COVE, FEBRUARY-AUGUST, 1985

STATION	DEPTH (m)	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
1	0			264.0	266.7	231.7	310.0	315.0
2	0			278.3	297.3	291.3	330.0	307.0
2	1			278.7	300.7	291.3	350.0	315.0
2	2			279.0	298.7	288.7	350.0	314.0
2	3			288.5		274.5	346.0	300.0
2	4						300.0	298.0
3	0			277.7	304.5	291.3	305.0	299.0
3	1			278.7	302.5	293.0	325.0	296.0
3	2			278.0	299.5	291.3	315.0	295.0
3	3			286.0	295.0	290.0	310.0	294.0
3	4			281.0			308.0	299.0
4	0			271.0	304.5	295.0	280.0	299.0
4	1			280.7	300.0	293.7	328.0	301.0
4	2			284.0	298.5	293.7	313.0	296.0
4	3			283.7	298.0	293.3	310.0	295.0
4	4			285.0	296.0			300.0
4	5			294.5				
5	0			270.3	297.3	287.7	338.0	309.0
5	1			273.3	300.7	289.7	320.0	312.0
5	2			275.0	300.0	287.7	318.0	308.0
5	3			273.0	298.3	284.7	310.0	307.0
5	4			283.5	286.5	283.0	300.0	cont'd

5	271.0	297.3	290.7	320.0	313.0
6	272.7	300.7	292.7	320.0	314.0
0	275.3	300.3	289.3	321.0	308.0
1	277.7	298.3	287.3	305.0	310.0
2	278.7	300.0	285.7	301.0	292.0
3	284.0	300.0	292.0	330.0	317.0
4	279.0	302.0	293.7	330.0	315.0
5	273.0	300.3	291.3	325.0	315.0
6	279.7	297.7	288.7	312.0	314.0
7	285.3	295.3	285.0	309.0	293.0
8	284.3	286.5	283.0	301.0	
9	286.0	288.3	286.7	320.0	305.0
0	289.5	298.0	293.3	320.0	313.0
1	266.3	299.3	288.7	330.0	311.0
2	280.3	300.0	288.0	312.0	310.0
3	281.3	291.5	287.3	310.0	305.0
4	281.3	300.7	291.0	322.0	302.0
5	270.3	300.3	296.3	330.0	318.0
6	270.3	295.7	292.3	320.0	313.0
7	278.7	300.5	287.7	315.0	312.0
8	280.0		285.3	310.0	307.0
9	279.7		281.3	315.0	283.0
0	279.3	299.0	293.7	302.0	314.0
1	278.0	297.3	292.3	326.0	318.0
2	272.3	297.0	288.0	320.0	318.0
3	272.7	295.3	288.7	320.0	318.0
4	273.0	297.0	284.3	305.0	311.0
5	280.7	295.5	286.0	302.0	309.0
6	279.3	295.0	284.3	300.0	
7	279.7	294.5	281.0	295.0	
8	279.3	291.0			
9	279.0	289.0			

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	262.0	297.0	320.0	350.0	335.0
minimum	150.0	220.0	215.0	280.0	250.0
stan.dev.	32.2	12.5	17.2	13.8	26.0
average	216.8	278.2	286.7	315.8	307.5
skewness	+	+	+	-	+

3	10	270.0	286.7	290.0	274.0	313.3	305.0
4	0	261.0	282.3	284.3	286.0	328.7	307.5
4	1	261.0	284.0	296.7	291.0	330.7	315.0
4	2	261.0	285.0	296.7	291.0	332.3	312.5
4	3	261.0	285.7	293.3	290.0	326.7	305.0
4	4	261.0	286.0	290.7	290.0	325.0	302.5
4	5	262.0	286.0	288.3	290.0	318.0	300.0
4	6	264.0	286.0	288.7	290.0	315.3	300.0
4	7	269.0	285.7	288.3	286.0	314.3	297.5
4	8	264.0	285.3	287.3	285.0	313.7	300.0
4	9	270.0	284.7	286.7	283.0	313.7	310.0
4	10	270.0	283.7	287.0	279.0	313.3	292.5
5	0	257.0	256.7	280.0	290.0	330.0	295.0
5	1	260.0	278.7	297.0	290.0	331.7	305.0
5	2	261.0	281.3	296.7	290.0	334.0	302.5
5	3	262.0	281.7	294.3	289.0	329.7	295.0
5	4	263.0	282.0	294.0	289.0	326.0	301.5
5	5	263.0	281.7	291.7	288.0	322.3	285.0
5	6	262.0	281.7	290.3	285.0	320.3	292.5
5	7	264.0	281.3	291.3	280.0	316.7	285.0
5	8	264.0	284.3	291.7	276.0	316.0	282.5
5	9	265.0	280.0	290.7	276.0	316.0	282.5
5	10	260.0	280.5	290.7	270.0	304.0	287.5
6	0	261.0	276.7	290.7	287.0	329.7	307.0
6	1	261.0	282.0	294.0	290.0	330.0	305.0
6	2	261.0	282.7	288.7	290.0	329.0	302.5
6	3	264.0	283.3	288.3	290.0	327.0	300.0
6	4	264.0	284.0	289.0	290.0	325.7	299.5
6	5	265.0	285.0	281.7	290.0	319.3	296.5
6	6	265.0	285.3	281.3	288.0	313.0	294.0
6	7	265.0	285.3	281.3	284.0	313.0	292.0
6	8	265.0	284.3	281.7	283.0	312.7	287.5
6	9	265.0	279.5	281.7	280.0	312.7	287.5
6	10	266.0	280.0	281.7	273.0	312.7	285.0
7	0	260.0	280.0	287.0	282.0	329.3	307.5

cont'd

7	1	260.0	279.7	296.7	288.0	330.0	307.5
7	2	264.0	282.0	295.0	291.0	330.0	305.0
7	3	263.0	283.3	293.7	290.0	326.0	302.5
7	4	265.0	284.0	293.0	290.0	319.7	300.0
7	5	265.0	284.0	291.3	290.0	320.0	300.0
7	6	266.0	284.3	291.0	289.0	349.0	297.5
7	7	266.0	283.7	291.3	290.0	315.0	294.5
7	8	266.0	283.3	291.7	284.0	313.7	287.5
7	9	265.0	283.0	292.0	282.0	313.3	287.5
7	10	270.0	275.0	290.0	273.0	327.5	287.5
8	0	249.0	267.3	283.7	282.0	333.3	295.0
8	1	259.0	273.0	296.7	288.0	335.7	302.5
8	2	260.0	282.3	294.0	291.0	333.3	300.0
8	3	261.0	283.3	293.3	290.0	329.0	297.5
8	4	260.0	283.7	292.7	290.0	324.7	295.0
8	5	262.0	283.7	291.0	290.0	319.3	295.0
8	6	262.0	283.3	290.3	289.0	315.7	294.0
8	7	262.0	283.3	290.7	290.0	315.7	290.0
8	8	262.0	283.0	290.0	284.0	315.3	291.5
8	9	262.0	282.7	289.7	282.0	315.0	290.0
8	10	259.0	283.0	288.7	273.0	314.3	287.5
9	0	258.0	277.0	279.3	282.0	330.7	300.0
9	1	260.0	281.0	292.3	288.0	330.7	310.5
9	2	260.0	283.3	293.3	290.0	331.0	307.5
9	3	260.0	283.3	292.7	290.0	328.3	306.5
9	4	260.0	282.7	291.0	290.0	327.3	300.0
9	5	260.0	282.7	291.0	290.0	323.3	298.5
9	6	260.0	282.3	290.0	289.0	321.7	308.0
9	7	260.0	282.3	290.0	290.0	316.0	310.0
9	8	260.0	282.3	289.7	284.0	314.7	309.0
9	9	261.0	282.3	289.7	282.0	315.3	305.0
9	10	263.0	282.7	289.7	273.0	316.3	303.5
10	0	260.0	271.7	293.7	293.0	328.0	315.0
10	1	260.0	279.7	297.0	295.0	330.7	320.0
10	2	259.0	281.3	296.7	293.0	331.3	315.0
10	3	260.0	283.0	293.7	290.0	329.7	307.5
10	4	259.0	283.0	291.3	290.0	324.3	305.0
10	5	260.0	283.0	290.0	290.0	321.0	300.5
10	6	260.0	282.3	289.3	288.0	318.7	297.5
10	7	262.0	282.3	289.3	284.0	315.3	297.5
10	8	262.0	282.3	289.0	284.0	315.0	295.0
10	9	262.0	282.3	288.3	284.0	315.3	299.5
10	10	262.0	282.0	288.0	271.0	314.0	300.0

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	270.0	298.0	312.0	295.0	390.0	350.0
minimum	210.0	200.0	190.0	150.0	220.0	210.0
stan.dev.	6.7	11.2	12.0	14.7	20.0	28.5
average	262.9	282.0	289.7	284.8	320.8	300.9
skewness	+	+	n	+	n	n

n = normal distribution

A.4.3. MONTHLY FIELD AVERAGES OF CONDUCTIVITY ($100 \times \mu \Omega / \text{cm}$), DARINOUTH COVE, FEBRUARY- AUGUST, 1985

STATION	DEPTH (m)	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
1	0	195.0	243.0	238.0	225.0	285.0	352.0	352.0
2	0	220.0	258.0	256.0	245.0	348.0	350.0	350.0
2	1	265.0	282.0	306.0	279.0	303.0	360.0	360.0
2	2	276.0	280.0	314.0	302.0	305.0	353.0	353.0
2	3	280.0	281.0	309.0	302.0	303.0	340.0	340.0
2	4	280.0	280.0	307.0	301.0	303.0	340.0	340.0
2	5	281.0		308.0		300.0		
2	6					298.0		
3	0	258.0	264.0	300.0	248.0	275.0	360.0	360.0
3	1	263.0	282.0	306.0	301.0	308.0	355.0	355.0
3	2	276.0	283.0	315.0	304.0	305.0	355.0	355.0
3	3	276.0	284.0	312.0	302.0	300.0	341.0	341.0
3	4	278.0	284.0	309.0	301.0	300.0	335.0	335.0
3	5	278.0	284.0	305.0		303.0	330.0	330.0
3	6	279.0	284.0	303.0				
4	0	227.0	264.0	253.0	245.0	265.0	345.0	345.0
5	0	254.0	268.0	309.0	261.0	285.0	358.0	358.0
5	1	260.0	282.0	316.0	296.0	300.0	355.0	355.0
5	2	265.0	284.0	317.0	301.0	308.0	351.0	351.0
5	3	275.0	285.0	314.0	300.0	305.0	340.0	340.0
5	4	275.0	285.0	311.0	300.0	300.0	338.0	338.0
5	5	276.0	285.0	310.0	300.0	300.0	332.0	332.0
5	6	277.0	285.0	304.0	298.0		330.0	330.0
5	7		290.0	311.0				
6	0	230.0	233.0	269.0	255.0	318.0	355.0	355.0
6	1	262.0	281.0	277.0	235.0	325.0	360.0	360.0
6	2	272.0	281.0	317.0	305.0	328.0	346.0	346.0
6	3	275.0	283.0	316.0	306.0	328.0	340.0	340.0
6	4	276.0	281.0	312.0	305.0	328.0	336.0	336.0
7	0	234.0	254.0	286.0	243.0	298.0	360.0	360.0
7	1	265.0	278.0	310.0	299.0	323.8	360.0	360.0
7	2	272.0	279.0	320.0	306.0	328.0	360.0	360.0
7	3	274.0	282.0	316.0	306.0	328.0	345.0	345.0
7	4	275.0	282.0	313.0	305.0	323.0	340.0	340.0
7	5	275.0	282.0	309.0	304.0	323.0	335.0	335.0
7	6	277.0	278.0	306.0		320.0	325.0	325.0

cont'd

8	259.0	267.0	272.0	247.0	298.0	335.0
8	267.0	277.0	316.0	298.0	323.0	355.0
8	273.0	279.0	315.0	306.0	320.0	360.0
8	275.0	281.0	314.0	305.0	320.0	340.0
8	274.0	281.0	313.0	305.0	320.0	335.0
8	275.0	281.0	309.0	303.0	320.0	333.0
8	266.0	281.0	305.0	298.0	315.0	330.0
8	262.0	281.0	309.0		315.0	325.0
9	234.0	265.0	280.0	248.0	318.0	360.0
9	259.0	271.0	318.0	291.0	324.0	350.0
9	268.0	278.0	320.0	305.0	320.0	350.0
9	270.0	279.0	315.0	305.0	320.0	335.0
9	273.0	280.0	313.0	305.0	318.0	333.0
9	273.0	280.0	308.0	303.0	318.0	333.0
9	274.0	281.0	306.0	302.0	315.0	330.0
9	273.0	280.0	313.0		315.0	325.0
9	275.0				313.0	
10	258.0	274.0	281.0	246.0	308.0	360.0
10	263.0	275.0	321.0	288.0	325.0	360.0
10	268.0	276.0	322.0	303.0	323.0	363.0
10	269.0	278.0	318.0	305.0	318.0	340.0
10	271.0	279.0	316.0	304.0	315.0	335.0
10	272.0	279.0	316.0	304.0	315.0	335.0
10	272.0	279.0	309.0	304.0	315.0	330.0
10	272.0	279.0	309.0	302.0	313.0	324.0
10	268.0		303.0			320.0
10	272.0					

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	287.0	290.0	349.0	312.0	380.0	363.0
minimum	130.0	190.0	200.0	190.0	250.0	320.0
stan. dev.	2.3	13.3	27.3	27.3	17.8	12.4
average	265.7	276.6	304.0	291.3	311.9	343.1
skewness	-		n			*

n = normal distribution

A.4.4. MONTHLY FIELD AVERAGES OF CONDUCTIVITY ($100 \times \mu\Omega/\text{cm}$), SACKVILLE STREET, FEBRUARY-AUGUST, 1985

STATION	DEPTH (m)	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
1	0	242.0	254.7	263.3	258.3	311.0	318.0	
2	0	263.3	276.7	293.3	288.3	315.0	337.0	
2	1	265.3	282.0	302.0	310.7	320.0	335.0	
2	2	265.0	283.0	301.0	302.3	319.0	334.0	
2	3	265.5	283.0	300.3	307.7	319.0	330.0	
2	4	268.3	283.0	298.7	316.0	316.5	329.0	
2	5	269.3	283.0	295.3	315.7	313.0	324.0	
2	6	269.6	283.0	293.7	309.7	312.5	322.0	
2	7	270.6	283.0	289.7	309.7	312.5	320.0	
2	8	271.0	283.0	287.7	273.5	312.5	319.0	
2	9	273.0	281.3	286.7	266.5	312.5		
2	10	290.0	278.0	286.0	265.0	315.0		
3	0	263.0	282.7	304.7	280.0	326.5	340.0	
3	1	264.7	283.0	305.7	280.0	327.5	343.0	
3	2	264.7	283.0	302.3	278.5	326.0	338.0	
3	3	264.7	283.0	301.0	278.0	325.0	333.0	
3	4	266.7	283.0	299.7	276.5	325.0	330.0	
3	5	267.3	282.7	296.7	275.5	321.5	328.0	
3	6	268.7	282.7	294.0	275.0	320.0	326.0	
3	7	269.0	282.7	290.0	274.5	320.0	323.0	
3	8	269.7	282.7	288.3	274.5	320.0	320.0	
3	9	271.7	282.7	287.3	273.5	320.0	318.0	cont'd

3	10	274.7	282.7	286.3	272.0	320.0	318.0
4	0	263.0	281.7	304.0	282.0	327.5	340.0
4	1	263.7	282.7	306.0	280.0	327.0	340.0
4	2	264.0	283.0	303.0	279.5	327.0	335.0
4	3	265.3	282.7	301.7	278.0	327.0	329.0
4	4	267.3	282.7	298.0	272.5	322.5	325.0
4	5	266.7	282.7	295.0	276.5	319.0	320.0
4	6	267.0	282.3	293.0	275.0	320.0	317.0
4	7	267.0	282.3	291.0	275.0	319.5	315.0
4	8	268.0	282.3	290.3	274.5	320.0	310.0
4	9	268.6	282.3	289.7	272.0	320.0	309.0
4	10	271.0	282.3	289.3	268.5	320.0	306.0
5	0	262.0	280.3	300.3	279.0	326.0	338.0
5	1	264.3	282.0	302.3	279.5	327.0	339.0
5	2	264.0	282.0	301.7	278.0	325.0	335.0
5	3	264.3	282.0	300.7	278.0	322.5	331.0
5	4	265.3	282.0	296.7	277.5	322.0	329.0
5	5	266.3	282.0	296.0	277.5	320.0	325.0
5	6	266.3	281.3	294.0	276.5	318.5	321.0
5	7	266.3	281.3	290.3	275.5	319.5	320.0
5	8	266.3	281.7	288.0	275.0	320.0	319.0
5	9	267.0	281.7	287.7	275.0	320.0	318.0
5	10	268.3	281.7	287.0	274.0	320.0	313.0
6	0	262.3	283.0	304.3	275.5	326.0	343.0
6	1	263.3	284.0	304.0	278.0	327.5	342.0
6	2	264.3	284.3	301.0	279.0	327.5	338.0
6	3	264.0	284.3	300.0	279.0	325.5	336.0
6	4	266.0	284.3	297.3	277.5	322.5	332.0
6	5	266.0	284.3	299.0	276.5	318.5	327.0
6	6	266.0	284.3	295.7	276.0	318.0	325.0
6	7	265.7	284.3	291.7	275.0	317.5	323.0
6	8	268.7	284.3	287.3	275.0	319.5	320.0
6	9	268.7	284.0	287.0	273.2	319.5	315.0
6	10	269.7	283.3	285.7	269.5	320.0	315.0

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	381.0	290.0	289.0	307.0	337.0	350.0
minimum	315.0	200.0	249.0	255.0	300.0	300.0
stat.dev.	9.3	15.3	5.6	10.0	8.1	12.1
average	376.9	266.4	282.1	294.9	320.8	327.0
skewness	-	-	-	-	-	n

n = normal distribution

A.4.5. MONTHLY FIELD AVERAGES OF CONDUCTIVITY (100 x $\mu\Omega$ /cm), PIER A, FEBRUARY-AUGUST, 1985

STATION	DEPTH (m)	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
1	0	390.0	236.0	234.0	265.7	195.0	269.0	269.0
2	0	381.0	258.0	285.0	298.0	252.5	325.0	325.0
2	1	380.0	258.7	285.0	304.0	270.0	330.0	350.0
2	2	380.0	260.7	286.0	272.7	276.0	330.0	350.0
2	3	380.0	261.3	286.0	303.7	275.0	326.0	350.0
2	4	380.0	262.0	285.5	294.3	269.5	322.5	341.0
2	5	380.0	262.3	285.5	293.7	269.5	322.5	340.0
2	6	380.0	263.7	285.0	291.7	270.5	322.5	332.0
2	7	380.0	263.7	286.0	289.7	269.0	322.5	328.0
2	8	380.0	264.0	285.5	288.7	268.5	322.5	325.0
2	9	380.0	265.0	285.0	287.7	265.0	322.0	325.0
2	10	380.0	267.0	285.0	287.7	263.5	322.0	325.0
3	0	369.0	256.0	283.0	307.7	260.5	327.5	350.0
3	1	378.0	260.3	286.0	308.0	275.5	325.5	352.0
3	2	350.0	260.7	288.0	307.3	274.5	325.5	351.0
3	3	380.0	261.0	286.0	301.7	268.0	325.5	351.0
3	4	380.0	261.0	285.5	297.0	265.0	322.5	350.0
3	5	380.0	261.0	284.6	293.0	265.0	321.5	351.0
3	6	381.0	262.3	284.6	292.0	263.5	322.0	345.0
3	7	351.0	262.3	287.0	291.0	269.5	323.5	335.0
3	8	351.0	262.0	285.0	288.0	268.0	322.0	322.0
3	9	351.0	266.7	285.5	287.3	264.0	322.0	322.0

cont'd

3	380.0	267.0	285.5	285.0	261.0	322.0	280.0
4	370.0	231.7	262.5	221.7	210.0	270.0	
5	369.0	258.3	283.0	307.3	278.0	281.0	
5	380.0	259.3	286.0	308.3	278.0	328.5	
5	380.0	260.0	285.5	304.7	278.0	329.0	
5	380.0	260.0	284.5	303.7	279.5	328.0	
5	380.0	260.3	284.0	299.3	274.5	327.5	
5	380.0	261.0	284.0	298.0	272.5	321.5	
5	380.0	261.0	283.5	292.0	272.5	321.5	
5	380.0	261.3	283.5	289.3	272.5	321.5	
5	380.0	262.3	283.5	287.0	268.0	321.5	
5	380.0	266.0	284.0	286.3	265.5	323.0	
5	380.0	266.7	284.0	286.3	260.0	323.0	
6	259.7	255.7	285.5	304.7	277.0	330.0	348.0
6	259.7	286.0	304.0	278.0	330.0	345.0	
6	260.7	285.5	302.3	272.5	325.0	330.0	
6	261.0	284.0	298.0	271.5	322.5	325.0	
6	261.7	284.0	294.3	269.5	322.5	321.0	
6	261.3	284.0	294.7	270.0	321.0	321.0	
6	262.0	284.0	289.7	268.5	322.0	320.0	
6	263.3	284.0	289.7	266.5	322.0	315.0	
6	264.0	283.5	287.3	261.5	323.5	310.0	
6	265.3	283.5	286.3	261.5	323.5	309.0	

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	381.0	280.0	380.0	310.0	299.0	338.0	352.0
minimum	369.0	220.0	220.0	150.0	180.0	220.0	280.0
stan.dev.	3.5	14.2	13.4	17.6	25.7	17.1	17.1
average	378.9	260.6	284.4	293.8	266.1	321.0	334.5
skewness							

A.5.1. MONTHLY FIELD AVERAGES OF THE SECCHI DISC (m), TUFTS COVE, FEBRUARY-AUGUST, 1985

STATION	DEPTH (m)	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
1		0.3	0.3	0.6	0.0	0.0	0.1	0.1
2		1.3	1.9	2.4	2.3	1.5	1.6	1.3
3		0.6	2.9	2.7	2.3	1.6	1.4	1.2
4		0.9	3.4	3.3	2.9	1.6	1.5	1.8
5		1.0	1.8	1.3	1.5	1.6	1.9	1.5
6		2.1	2.0	1.5	1.8	1.4	1.5	1.5
7		2.0	2.7	1.4	1.6	1.4	2.3	2.0
8		0.5	3.7	1.4	1.6	2.0	0.9	0.8
9		0.2	4.4	3.6	2.8	2.0	2.0	0.9
10		3.5	4.6	3.3	3.4	2.0	1.9	1.6

A.5.2. MONTHLY FIELD AVERAGES OF THE SECCHI DISC (m), DUFFUS STREET, FEBRUARY-AUGUST, 1985

STATION	DEPTH (m)	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
1	0.3	0.3	0.7	0.4	0.3	0.7	0.1	0.2
2	1.0	1.0	2.7	2.3	3.4	2.0	0.7	2.2
3	5.0	5.0	3.8	3.7	3.2	1.7	2.2	2.5
4	7.0	7.0	3.0	4.1	3.5	2.6	2.0	2.0
5	1.0	1.0	3.2	3.0	3.3	2.0	1.5	1.5
6	2.0	2.0	4.8	3.4	3.8	2.1	1.4	2.0
7	2.0	2.0	3.8	3.5	3.8	2.3	2.0	1.9
8	1.0	1.0	2.7	2.3	3.3	2.0	1.7	1.2
9	4.0	4.0	3.3	3.2	3.3	2.2	2.2	2.1
10	3.0	3.0	3.8	3.0	3.3	2.3	2.0	2.1

A.5.3. MONTHLY FIELD AVERAGES OF THE SECCHI DISC (m), DARTMOUTH COVE, FEBRUARY-AUGUST, 1985

STATION	DEPTH (m)	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
1	0.5	0.5	0.5	0.5	0.2	0.2	0.1	0.3
2			3.7	1.7	2.2	1.4	1.7	1.1
3			4.1	2.3	2.4	1.6	1.9	1.7
4			0.7	0.4	0.4	0.2	1.4	0.8
5			3.6	2.4	2.5	2.2	2.8	1.5
6			1.8	2.4	1.2	1.0	1.7	1.0
7			3.5	2.2	1.3	1.8	1.6	1.3
8			4.3	3.4	1.4	1.9	2.3	2.0
9			3.7	3.5	2.7	2.8	2.9	1.8
10			5.3	3.9	2.5	2.8	3.0	2.0

A.5.4. MONTHLY FIELD AVERAGES OF THE SECCHI DISC (m), SACKVILLE STREET, FEBRUARY-AUGUST, 1985

STATION	DEPTH (m)	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
1		0.7	0.6	0.3	0.1	0.2	0.1	0.1
2		1.0	2.0	0.8	1.1	1.2	0.7	1.3
3		3.0	5.3	4.4	3.6	2.0	2.6	2.4
4		4.0	5.8	5.0	4.0	2.2	2.4	2.2
5		2.5	5.5	4.4	3.6	2.0	2.2	2.0
6		5.0	6.2	3.8	3.9	1.3	2.4	2.1

A.5.5. MONTHLY FIELD AVERAGES OF THE SECCHI DISC (m), PIER A, FEBRUARY-AUGUST, 1985

STATION	DEPTH (m)	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST
1		0.3	0.3	0.4	0.3	0.2	0.1	0.0
2		2.5	2.5	4.0	2.8	1.1	1.2	2.5
3		3.5	4.0	4.0	3.3	1.8	1.4	0.0
4		0.8	0.3	0.3	0.6	0.1	0.2	1.3
5		3.8	6.0	4.8	3.8	1.5	1.4	2.5
6		3.5	5.0	4.2	3.9	2.0	2.4	2.3

A.6.1 MONTHLY FIELD DATA FOR OLAND'S OUTFALL (Young Street),
JUNE, 1985

- 365 -

STATION	D.O. (mg/L)	TEMPERATURE (°C)	SALINITY (o/oo)	CONDUCTIVITY (100 x $\mu\Omega$ cm)	SECCHI (m)
1-0	8.3	10.5	19.9	220.0	0.1
2-0	8.1	9.5	23.0	255.0	1.0
2-1	8.3	9.5	23.0	256.0	
2-2	8.4	8.5	24.0	259.0	
2-3	8.6	7.0	25.0	260.0	
2-4	8.8	6.0	25.9	259.0	
2-5	8.9	5.5	26.0	258.0	
2-6	9.0	5.0	26.6	257.0	
2-7	9.1	4.9	26.6	257.0	
2-8	9.1	4.9	26.6	256.0	
2-9	9.1	4.8	26.6	255.0	
2-10	9.1	4.5	27.0	254.0	
3-0	8.3	9.8	23.0	255.0	2.0
3-1	8.4	9.0	23.2	258.0	
3-2	8.4	8.6	24.0	259.0	
3-3	8.6	8.0	24.1	260.0	
3-4	8.6	8.2	24.0	260.0	
3-5	8.6	7.5	24.8	256.0	
3-6	8.9	7.7	24.5	252.0	
3-7	9.0	5.0	26.1	251.0	
3-8	9.0	4.5	26.8	251.0	
3-9	9.1	4.5	26.2	251.0	
3-10	9.1	4.2	27.0	251.0	
4-0	8.2	9.3	22.8	250.0	2.0
4-1	8.4	8.6	23.0	250.0	
4-2	8.5	8.2	25.0	250.0	
4-3	8.6	8.1	25.0	269.0	
4-4	8.7	7.3	25.2	270.0	
4-5	8.9	6.5	26.5	269.0	
4-6	9.0	5.3	27.1	268.0	
4-7	9.0	5.0	27.5	267.0	
4-8	9.1	4.9	27.6	267.0	
4-9	9.1	4.9	27.7	268.0	
4-10	9.1	4.9	27.7	269.0	
5-0	8.3	9.5	24.0	268.0	2.0
5-1	8.3	8.5	25.0	270.0	
5-2	8.4	8.6	25.0	269.0	
5-3	8.6	8.4	25.0	270.0	
5-4	8.6	8.0	25.5	270.0	
5-5	8.8	6.4	26.9	270.0	
5-6	8.9	5.5	27.3	269.9	
5-7	9.0	5.1	27.3	269.0	
5-8	9.0	5.0	27.5	268.0	
5-9	9.1	4.9	27.5	268.0	
5-10	9.2	4.7	28.0	265.0	
6-0	8.2	9.9	23.5	260.0	0.8
6-1	8.2	9.1	24.0	268.0	
6-2	8.3	8.9	24.8	269.0	
6-3	8.5	8.8	25.0	270.0	
6-4	8.5	8.0	25.5	270.0	
6-5	8.8	5.2	25.5	268.0	
6-6	8.9	5.0	27.5	267.0	
6-7	8.9	4.9	27.9	265.0	
6-8	9.0	4.7	27.8	265.0	
6-9	9.0	4.4	28.0	265.0	
6-10	9.0	4.3	28.0	265.0	
7-0	8.2	9.7	23.5	261.0	1.8
7-1	8.2	8.9	24.5	268.0	
7-2	8.3	8.9	24.6	268.0	
7-3	8.4	8.3	25.0	269.0	
7-4	8.6	6.5	27.0	270.0	
7-5	8.8	5.3	27.7	268.0	
7-6	8.7	5.2	27.8	269.0	
7-8	8.8	5.0	27.8	268.0	
7-9	8.9	5.0	27.0	270.0	
7-10	8.9	5.0	27.5	268.0	

A.6.2 MONTHLY FIELD DATA FOR OLAND'S OUTFALL (YOUNG STREET),
JULY, 1985

STATION	D.O. (mg/L)	TEMPERATURE (°C)	SALINITY (o/oo)	CONDUCTIVITY (100 x $\mu S/cm$)	SECCHI (m)
1-0	7.4	14.7	29.5	330.0	0.1
2-0	7.6	15.0	25.5	315.0	0.3
2-1	7.7	14.5	26.0	345.0	
2-2	8.1	9.5	25.5	325.0	
2-3	8.2	7.0	27.0	300.0	
2-4	8.3	6.3	26.0	340.0	
2-5	8.2	6.0	27.5	345.0	
2-6	8.3	17.0	25.5	350.0	
3-0	7.8	15.0	26.0	315.0	2.3
3-1	8.0	14.8	26.0	330.0	
3-2	8.1	10.0	28.5	360.0	
3-3	8.1	10.0	25.0	310.0	
3-4	8.3	7.0	29.0	335.0	
3-5	8.3	6.5	31.0	365.0	
3-6	8.4	6.5	33.5	390.0	
3-7	8.3	6.2	28.0	365.0	
3-8	8.3	6.0	27.0	390.0	
3-9	8.3	5.0	28.5	360.0	
3-10	8.3	5.0	28.5	360.0	
4-0	8.0	13.0	26.0	330.0	2.1
4-1	8.1	14.5	26.5	330.0	
4-2	8.2	10.5	26.0	330.0	
4-3	8.2	10.5	26.5	340.0	
4-4	8.5	9.0	27.0	310.0	
4-5	8.5	9.0	25.0	360.0	
4-6	8.5	6.0	26.0	300.0	
4-7	8.3	6.5	26.0	300.0	
4-8	8.3	6.5	27.0	290.0	
4-9	8.1	5.0	26.5	290.0	
4-10	8.1	5.0	26.0	290.0	
5-0	7.8	15.0	25.0	320.0	1.1
5-1	8.0	12.5	26.0	345.0	
5-2	8.1	10.0	26.0	310.0	
5-3	8.3	7.6	26.0	300.0	
5-4	8.2	6.5	26.0	295.0	
5-5	8.2	6.0	26.0	295.0	
5-6	8.2	5.2	26.5	290.0	
5-7	8.1	5.0	26.0	290.0	
5-8	8.0	5.0	26.5	290.0	
5-9	8.0	5.0	26.5	290.0	
5-10	8.0	5.0	26.5	290.0	
6-0	8.0	14.2	25.5	340.0	1.9
6-1	8.1	9.5	26.0	310.0	
6-2	8.1	8.0	31.0	330.0	
6-3	8.2	6.5	29.0	330.0	
6-4	8.2	6.0	32.0	335.0	
6-5	8.1	6.0	32.0	340.0	
6-6	8.1	5.0	28.5	330.0	
6-7	8.1	4.7	29.5	330.0	
6-8	8.3	4.0	29.3	320.0	
6-9	8.1	4.0	31.5	330.0	
6-10	8.1	4.0	31.5	330.0	

A.6.3 MONTHLY FIELD DATA FOR OLAND'S OUTFALL (YOUNG STREET),
AUGUST, 1985

STATION	D.O. (mg/L)	TEMPERATURE (°C)	SALINITY (o/oo)	CONDUCTIVITY (100 x $\mu\Omega$ /cm)	SECCHI (m)
1-0	8.4	15.0	17.5	235.0	0.2
2-0	9.0	14.0	24.5	305.0	1.5
2-1	9.4	13.9	24.9	305.0	
2-2	10.1	12.8	24.8	300.0	
2-3	10.5	13.0	24.8	299.0	
2-4	10.8	12.0	24.8	225.0	
2-5	10.9	12.0	24.8	295.0	
2-6	10.9	11.8	25.0	292.0	
2-7	10.9	11.2	25.0	290.0	
2-8	10.3	11.0	25.0	290.0	
2-9	10.3	11.1	25.0	290.0	
2-10	10.1	10.5	25.1	288.0	
3-0	8.9	14.0	24.0	301.0	1.7
3-1	7.9	13.9	24.5	301.0	
3-2	8.9	13.9	24.5	301.0	
3-3	9.5	13.5	24.5	301.0	
3-4	10.1	13.0	24.5	300.0	
3-5	10.5	12.8	24.5	299.0	
3-6	10.7	12.8	24.5	299.0	
3-7	10.8	11.8	24.5	290.0	
3-8	10.8	11.3	24.5	290.0	
3-9	10.9	11.2	24.5	289.0	
3-10	10.9	11.1	24.5	288.0	
4-0	9.3	14.0	24.1	302.0	1.9
4-1	8.7	13.3	24.5	302.0	
4-2	8.4	13.2	24.5	301.0	
4-3	8.9	13.2	24.5	301.0	
4-4	9.7	13.0	24.8	301.0	
4-5	10.0	13.0	24.5	300.0	
4-6	10.5	12.5	24.9	299.0	
4-7	10.5	12.0	24.9	295.0	
4-8	10.6	11.4	25.0	290.0	
4-9	10.5	10.9	25.0	288.0	
4-10	10.5	10.9	25.0	285.0	
5-0	9.3	14.3	24.2	308.0	2.0
5-1	7.9	14.0	24.2	305.0	
5-2	8.0	14.0	24.5	310.0	
5-3	9.1	14.0	25.0	310.0	
5-4	10.1	14.0	24.8	310.0	
5-5	10.3	13.5	25.1	310.0	
5-6	10.7	12.0	25.9	299.0	
5-7	11.0	12.0	25.0	299.0	
5-8	11.1	12.0	25.0	298.0	
5-9	11.1	11.8	25.0	295.0	
5-10	11.1	10.0	25.0	285.0	
6-0	7.7	14.0	24.5	305.0	1.7
6-1	7.1	14.0	24.9	310.0	
6-2	7.1	14.0	25.0	310.0	
6-3	8.0	14.0	25.1	310.0	
6-4	9.0	14.0	25.0	310.0	
6-5	9.7	13.8	25.0	310.0	
6-6	9.9	13.5	25.1	310.0	
6-7	10.3	12.8	25.2	310.0	
6-8	10.4	13.0	24.9	305.0	
6-9	10.7	12.2	25.0	300.0	
6-10	10.6	11.1	25.1	295.0	

A.7.1 MONTHLY FIELD DATA FOR HISTORIC PROPERTIES OUTFALL,
JUNE, 1985

STATION	D.O. (mg/L)	TEMPERATURE (°C)	SALINITY (o/oo)	CONDUCTIVITY (100 x $\mu\Omega$ /cm)	SECCHI (m)
1-0	8.4	8.0	25.7	270.0	0.0
2-0	8.4	8.0	22.2	250.0	2.2
2-1	8.4	7.6	24.5	253.0	
2-2	8.6	7.4	23.5	250.0	
2-3	8.8	7.2	24.0	251.0	
2-4	8.9	7.0	25.1	251.0	
2-5	9.2	6.5	25.0	260.0	
2-6	9.3	5.1	26.0	257.0	
2-7	9.3	5.1	26.0	257.0	
2-8	9.3	4.9	26.2	252.0	
2-9	9.4	3.2	28.5	250.0	
2-10	9.4	2.5	28.1	248.0	
3-0	8.6	8.0	24.0	257.0	2.1
3-1	8.6	7.9	24.1	258.0	
3-2	8.7	7.4	25.1	263.0	
3-3	8.8	7.2	25.2	263.0	
3-4	8.8	6.5	26.0	262.0	
3-5	8.8	6.0	26.3	262.0	
3-6	8.9	6.0	26.1	263.0	
3-7	8.9	5.4	26.6	260.0	
3-8	8.9	4.9	26.6	258.0	
3-9	9.0	3.5	27.1	251.0	
3-10	8.9	3.0	27.2	250.0	
4-0	8.6	7.8	25.0	261.0	2.0
4-1	8.6	7.8	25.0	260.0	
4-2	8.6	7.5	25.0	260.0	
4-3	8.7	6.9	25.2	260.0	
4-4	8.6	6.9	25.0	260.0	
4-5	8.8	6.2	25.8	258.0	
4-6	8.7	6.2	25.8	260.0	
4-7	8.8	5.7	26.0	260.0	
4-8	8.9	5.0	25.1	252.0	
4-9	8.8	3.5	28.0	249.0	
4-10	8.8	4.0	26.8	255.0	
5-0	8.4	8.1	24.3	260.0	2.0
5-1	8.5	7.2	25.0	261.0	
5-2	8.6	7.0	25.1	261.0	
5-3	8.6	6.9	25.2	260.0	
5-4	8.6	6.9	25.0	260.0	
5-5	8.6	6.5	25.5	258.0	
5-6	8.7	5.9	25.9	260.0	
5-7	8.6	4.6	26.0	252.0	
5-8	8.6	4.6	26.2	252.0	
5-9	8.6	4.5	26.2	252.0	
5-10	8.8	3.0	27.0	248.0	

A.7.2 MONTHLY FIELD DATA FOR HISTORIC PROPERTIES OUTFALL,
JULY, 1985

STATION	D.O. (mg/L)	TEMPERATURE (°C)	SALINITY (o/oo)	CONDUCTIVITY (100 x $\mu\Omega$ /cm)	SECCHI (m)
1-0	7.8	12.0	29.0	360.0	1.0
2-0	8.0	12.0	28.5	365.0	2.2
2-1	8.1	10.0	33.0	365.0	
2-2	8.1	10.0	31.5	365.0	
2-3	8.1	5.5	33.0	365.0	
2-4	8.1	5.5	33.0	335.0	
2-5	8.2	4.5	33.0	330.0	
2-6	8.1	4.1	32.0	335.0	
2-7	8.1	4.0	31.5	330.0	
2-8	8.0	4.0	33.0	325.0	
2-9	8.0	3.3	34.0	330.0	
2-10	8.0	3.3	34.0	330.0	
3-0	8.0	13.2	31.0	380.0	
3-1	8.1	11.5	32.5	365.0	
3-2	8.0	10.0	31.0	370.0	
3-3	8.2	6.0	32.0	345.0	
3-4	8.2	5.8	31.5	345.0	
3-5	8.2	5.5	33.0	340.0	
3-6	8.2	5.0	31.0	335.0	
3-7	8.2	5.0	31.0	340.0	
3-8	8.1	4.5	33.0	320.0	
3-9	8.1	4.0	34.0	335.0	
3-10	8.1	4.0	31.0	345.0	
4-0	7.8	13.0	31.0	370.0	2.1
4-1	8.0	11.0	31.0	360.0	
4-2	8.0	9.0	31.0	350.0	
4-3	8.0	7.0	31.0	350.0	
4-4	8.1	6.0	34.0	340.0	
4-5	8.1	5.5	31.0	340.0	
4-6	8.1	4.2	31.0	325.0	
4-7	8.0	4.0	32.0	320.0	
4-8	8.0	4.0	32.0	335.0	
4-9	8.0	4.0	32.0	325.0	
4-10	8.0	4.0	31.0	335.0	
5-0	8.0	13.0	29.0	370.0	2.1
5-1	8.0	12.0	31.0	370.0	
5-2	8.1	8.0	32.0	350.0	
5-3	8.2	6.0	32.5	345.0	
5-4	8.2	5.3	33.0	335.0	
5-5	8.2	4.6	34.0	335.0	
5-6	8.1	4.0	35.0	330.0	
5-7	8.0	4.0	33.0	335.0	
5-8	8.0	4.0	33.0	335.0	
5-9	8.0	4.0	33.0	335.0	
5-10	8.0	4.0	34.0	330.0	

A.7.3 MONTHLY FIELD DATA, HISTORIC PROPERTIES OUTFALL,
AUGUST, 1985

STATION	D.O. (mg/L)	TEMPERATURE (°C)	SALINITY (o/oo)	CONDUCTIVITY (100 x $\mu\Omega$ /cm)	SECCHI (m)
1-0	7.4	15.5	25.1	330.0	0.3
2-0	7.3	16.0	25.0	320.0	2.0
2-1	7.5	15.8	25.1	330.0	
2-2	8.1	15.5	25.1	325.0	
2-3	8.5	14.5	26.0	320.0	
2-4	8.8	14.5	25.5	320.0	
2-5	8.9	14.3	26.0	320.0	
2-6	9.2	14.0	25.5	319.0	
2-7	9.3	14.1	25.5	318.0	
2-8	9.5	14.0	25.5	318.0	
2-9	9.8	12.8	23.2	285.0	
2-10	10.2	11.8	23.0	275.0	
3-0	7.7	15.6	23.1	301.0	2.0
3-1	7.4	15.1	23.1	299.0	
3-2	7.7	15.1	23.0	295.0	
3-3	8.5	15.0	23.0	290.0	
3-4	8.9	14.6	23.8	301.0	
3-5	9.1	14.5	24.8	302.0	
3-6	9.5	14.1	23.0	302.	
3-7	9.6	13.4	23.1	298.0	
3-8	9.9	12.8	22.5	285.0	
3-9	10.0	11.8	23.0	265.0	
3-10	9.8	10.9	23.5	271.0	
4-0	7.6	15.8	24.1	315.0	2.0
4-1	7.3	15.5	24.0	315.0	
4-2	7.4	15.5	24.0	310.0	
4-3	7.9	15.5	23.5	305.0	
4-4	8.4	15.5	23.5	302.0	
4-5	8.8	15.1	23.2	301.0	
4-6	9.1	14.0	23.2	295.0	
4-7	8.9	13.6	23.5	290.0	
4-8	9.2	13.0	23.5	290.0	
4-9	9.2	11.8	23.5	280.0	
5-0	8.0	15.8	25.0	320.0	2.2
5-1	7.5	15.6	25.0	320.0	
5-2	6.9	14.8	25.0	295.0	
5-3	7.9	14.5	25.0	315.0	
5-4	8.7	14.1	24.9	310.0	
5-5	9.1	14.0	24.5	310.0	
5-6	9.4	13.3	25.0	308.0	
5-7	9.7	12.5	25.0	300.0	
5-8	8.1	11.8	25.0	295.0	
5-9	8.1	11.5	25.0	295.0	

APPENDIX B

Halifax Harbour Monthly Laboratory Data



B.1.1 MONTHLY AVERAGES OF CHEMICAL OXYGEN DEMAND (mg/L)
FOR THE TUFTS COVE SEWER OUTFALL, APRIL-AUGUST, 1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH	FEB (m)	MAR	APR	MAY	JUNE	JULY	AUG
Manhole					186.4	248.9	68.4	48.5	363.3
1	Plume	0			780.7	437.8	294.5	327.0	231.0
2	50.0	0			425.0	325.4	341.7	222.0	94.7
2A	50.0	1.0-3.0			476.7	424.2	178.9	253.0	99.0
3	100.0	0			368.1	469.2	120.7	359.0	58.3
3A	100.0	2.0-4.0			377.0	225.8	90.3	248.0	81.8
4	150.0	0			293.4	225.4	141.5	364.0	58.8
4A	150.0	1.0-4.0			89.7	461.0	67.9	190.0	91.3
5	50.0	0			121.0	300.4	82.0	306.0	98.8
5A	50.0	3.0-4.5			179.1	311.3	125.4	306.0	117.7
6	100.0	0			133.3	357.0	140.6	248.0	97.5
6A	100.0	2.5-4.0			80.8	243.1	77.8	375.0	98.7
7	150.0	2.5-4.0			176.1	259.2	61.2	137.0	91.2
7A	150.0	3.5-5.0			307.6	377.1	258.8	253.0	96.0
8	50.0	0			305.3	286.4	111.3	264.0	219.1
8A	50.0	2.5-4.0			204.8	309.6	188.7	243.0	251.3
9	100.0	0			89.3	324.7	127.5	275.0	302.7
9A	100.0	5.0-6.0			138.6	290.6	97.4	275.0	180.3
10	150.0	0			267.4	338.4	81.6	306.0	103.3
10A	150.0	4.0-7.0			305.7	341.6	93.8	269.0	159.3

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	1321.5	701.8	594.1	375.0	692.0
minimum	23.6	17.3	4.6	137.0	18.0
stan.dev.	277.7	197.4	122.3	59.3	124.7
average	270.0	333.8	141.1	274.7	135.8
skewness	+	-	-	+	+

B.1.2 MONTHLY AVERAGES OF CHEMICAL OXYGEN DEMAND (mg/L)
FOR DUFFUS STREET SEWER OUTFALL, APRIL-AUGUST, 1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FEB	MAR	APR	MAY	JUNE	JULY	AUG
Manhole					105.9	161.3	109.2	158.8	294.0
1	Plume	0			114.3	185.5	94.0	254.0	124.0
2	50.0	0			75.0	133.2	85.0	67.8	125.5
2A	50.0	9.0-13			76.1	141.0	143.0	119.0	98.0
3	100.0	0			107.1	109.5	93.0	50.0	110.3
3A	100.0	20-23			134.3	74.4	125.0	31.3	116.3
4	150.0	0			160.1	48.6	81.0	80.0	102.5
4A	150.0	20-24			203.0	157.7	85.0	84.5	104.0
5	50.0	0			80.1	75.6	152.0	62.1	117.8
5A	50.0	8.0-8.0			206.5	56.6	54.0	65.9	111.3
6	100.0	10-13			225.8	49.3	108.0	82.6	110.5
6A	100.0	10-13			121.2	77.3	157.0	197.0	101.8
7	150.0	0			180.9	46.2	251.0	70.1	99.0
7A	150.0	12-15			199.8	85.5	175.0	147.0	92.8
8	50.0	0			72.7	40.7	197.0	314.0	89.3
8A	50.0	13-16			99.4	115.5	381.0	104.0	101.0
9	100.0	0			154.8	43.6	188.0	92.8	128.3
9A	100.0	15-18			246.5	65.9	233.0	95.1	103.8
10	150.0	0			204.2	52.7	220.0	101.0	146.5
10A	150.0	20-23			113.6	48.9	260.0	97.6	155.8

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	462.2	325.3	727.0	727.0	180.5
minimum	11.0	6.1	50.0	4.6	48.0
stan.dev.	111.5	61.5	120.7	121.0	33.9
average	153.8	85.6	148.6	112.3	111.5
skewness	+	+	+	+	-

B.1.3 MONTHLY AVERAGES OF CHEMICAL OXYGEN DEMAND (mg/L) FOR
THE DARTMOUTH COVE SEWER OUTFALL, APRIL-AUGUST, 1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FEB	MAR	APR	MAY	JUNE	JULY	AUG
Manhole					96.8	533.0	272.0	195.0	140.0
1	Plume 1	0			268.5	107.6	151.8	108.6	137.3
2	75	0			176.0	103.7	152.1	126.0	116.3
2A	75	5.0-7.0			165.4	57.1	149.1	53.0	93.3
3	125	0			179.8	45.4	68.8	114.8	136.0
3A	125	4.5-7.0			61.5	97.9	71.5	296.0	109.5
4	Plume 2	0			147.5	59.9	107.8	148.0	118.3
5	50	0			289.4	19.8	103.1	128.3	130.5
5A	50	5.5-6.0			170.8	54.4	97.4	92.1	113.5
6	50	0			112.5	115.3	130.0	124.4	129.8
6A	50	4.0-5.0			124.8	118.5	88.4	110.1	137.5
7	50	0			205.0	80.9	98.5	130.2	97.8
7A	50	4.5-6.0			85.6	38.9	65.6	114.7	110.0
8	100	0			91.0	108.5	98.2	116.7	93.8
8A	100	3.5-7.0			92.3	76.0	132.3	130.4	136.3
9	150	0			46.3	92.1	128.3	145.7	92.0
9A	150	7.0-7.0			71.0	81.4	124.2	110.3	116.5
10	200	0			78.8	99.3	124.0	161.0	76.3
10A	200	10			61.0	69.0	137.8	109.8	97.8

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	871.2	250.0	233.9	290.0	172.5
minimum	14.8	2.9	27.8	11.6	60.0
stan. dev.	216.3	67.0	51.2	62.9	26.4
average	216.1	77.6	112.7	105.4	113.4
skewness	+	+	+	+	+

B.1.4 MONTHLY AVERAGES OF CHEMICAL OXYGEN DEMAND (mg/L) FOR
THE SACKVILLE STREET SEWER OUTFALL, APRIL-AUGUST, 1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FEB	MAR	APR	MAY	JUNE	JULY	AUG
Manhole					523.6		410.4	216.5	217.5
1	Plume	0			197.9	148.8	158.5	150.5	102.8
2	50	0			148.3	83.4	126.4	208.7	100.5
2A	50	10			317.8	84.9	90.9	160.0	69.0
3	100	0			316.9	60.6	185.6	149.0	74.8
3A	100	16			206.5	79.7	207.7	126.6	70.0
4	150	0			271.1	84.4	155.5	149.5	91.3
4A	150	19.5			196.5	89.0	175.9	134.4	103.5
5	50	0			153.6	26.6	154.0	129.5	65.8
5A	50	11			185.1	102.3	212.4	102.4	96.3
6	50	0			323.8	167.2	200.8	88.0	69.3
6A	50	10			128.0	77.6	184.8	86.9	62.0

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	869.0	438.0	410.4	225.5	217.5
minimum	14.8	8.3	32.2	25.8	45.0
stan.dev.	224.6	87.6	99.2	60.6	37.7
average	244.8	91.0	175.2	138.1	88.2
skewness	-	+	+	-	n

n = normal distribution

B.1.5 MONTHLY AVERAGES OF CHEMICAL OXYGEN DEMAND (mg/L)
FOR THE PIER A OUTFALL, APRIL-AUGUST, 1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH	FEB (m)	MAR	APR	MAY	JUNE	JULY	AUG
Manhole					682.6		385.6	275.0	125.0
1	Plume 1	0			180.1	200.5	111.0	187.8	125.0
2	200	0			69.0	169.5	83.0	74.8	93.0
2A	200	12			93.8	181.4	65.9	110.3	94.4
3	400	0			76.7	176.0	75.8	88.6	58.8
3A	400	17			174.1	194.3	96.1	112.1	65.8
4	Plume 2	0			97.5	222.8	152.2	232.7	115.0
5	50	0			69.8	162.3	156.9	105.8	59.5
5A	50	19			74.0	136.0	123.9	108.2	70.3
6	100	0			125.7	184.9	289.3	69.7	70.8
6A	100	9			183.2	229.1	136.6	54.0	94.3

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	431.2	432.5	589.6	321.5	145.0
minimum	27.1	6.4	7.2	11.1	35.0
stan.dev.	106.7	114.9	104.5	67.9	28.0
average	114.1	185.0	129.1	112.7	82.5
skewness	+	+	+	+	-

**D.2.1 MONTHLY AVERAGES OF BIOCHEMICAL OXYGEN DEMAND
(mg/L) FOR THE TUPIS CIVE SEWER OUTFALL
SEPTEMBER, 1984-1985**

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG
Manhole														
1		0	42.1	63.4	64.1	42.1		11.0	64.0	172.0	150.0	50.0	69.0	140.0
2	50	0	9.1	32.2	8.1	4.0		45.5	28.9	58.2	36.8	49.0	17.8	122.0
2A	50	1.0-3.0	4.8	9.3	3.9	4.0		11.0	7.9	3.0	9.1	7.2	9.7	21.8
3	100	0	3.6	10.2	2.4	3.9		5.1	4.3	2.4	4.6	6.4	5.1	7.4
3A	100	2.0-4.0	3.7	5.0	1.9	1.5		26.8	3.2	2.1	4.6	3.5	9.1	20.0
4	100	0	1.3	7.6	5.3	2.2		4.8	2.3	2.0	3.2	3.5	2.1	4.9
4A	100	1.0-4.0	2.7	3.4	1.3	4.2		15.8	6.2	2.2	3.9	3.8	7.8	4.9
5	50	0	21.7	11.8	11.4	18.7		5.1	2.7	1.9	2.0	3.1	2.1	3.3
5A	50	3.0-4.5	12.5	6.3	3.5	6.8		14.2	10.7	14.8	7.9	6.2	3.1	12.8
6	100	0	3.9	19.5	7.3	7.0		5.4	3.2	3.8	5.3	3.1	2.9	5.8
6A	100	2.5-4.0	3.9	4.4	3.0	3.3		4.7	4.7	12.2	7.2	1.6	3.0	7.0
7	150	0		12.2	7.0	7.4		2.4	2.7	4.2	2.9	6.0	1.6	4.1
7A	150	3.5-5.0		4.3	2.3	2.4		7.0	3.6	7.8	5.2	4.6	2.8	4.0
8	50	0	15.9	23.1	5.1	4.9		1.5	2.2	1.9	3.4	3.3	0.8	3.2
8A	50	2.5-4.0	5.2	7.1	4.2	4.2		13.6	7.4	4.0	13.7	5.2	4.4	55.5
9	100	0	4.6	12.8	7.2	2.9		5.9	2.4	2.7	2.2	3.9	1.4	5.5
9A	100	5.0-6.0	5.9	4.1	2.5	2.5		16.9	2.8	5.0	4.0	5.2	2.4	7.2
10	150	0		7.0	6.4	2.0		3.0	2.2	1.8	2.0	3.0	0.5	3.0
10A	150	4.0-7.0		3.5	2.4	2.3		1.8	2.2	1.8	3.5	5.6	2.4	5.8
								2.4	1.5	3.8	1.5	3.0	0.0	3.3
STATISTICAL ANALYSIS OF THE DAILY DATA														
maximum			60.5	128.0	143.7	150.0		69.0	94.0	138.5	41.0	150.0	17.8	225.0
minimum			1.0	2.2	1.0	1.5		0.8	1.0	1.2	1.2	1.6	0.5	2.5
stan.dev.			11.3	21.3	19.6	24.3		13.2	15.1	18.5	8.7	20.3	4.3	36.6
average			7.8	13.6	9.0	9.8		11.2	7.3	7.3	7.5	7.9	4.4	17.6
skewness			+		+			+	+		+		+	+

**B.2.2 MONTHLY AVERAGES OF BIOCHEMICAL OXYGEN DEMAND
(mg/l) FOR THE DUFFUS STREET SEWER OUTFALL
SEPTEMBER, 1984-1985**

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG
Manhole														
1	Plume	0	28.7	28.7	29.7	25.0		40.5	30.0	37.5	61.0	115.0	78.0	58.4
2	50	0	19.4	17.5	9.5	13.1		16.4	30.4	29.8	18.5	19.0	55.2	27.5
2A	50	9.0-13	3.9	6.9	3.3	6.1		3.9	7.4	3.9	2.7	2.1	8.1	10.0
3	100	0	6.0	8.7	4.0	5.1		5.1	3.5	1.9	3.7	2.7	2.0	2.0
3A	100	20-23	2.6	3.5	2.9	4.7		3.1	3.2	1.0	1.0	1.5	3.0	3.5
4	150	0	5.8	5.8	3.7	3.3		1.6	5.8	1.6	2.7	1.6	3.0	3.8
4A	150	20-24	5.1	5.1	3.0	3.8		2.5	2.6	1.2	1.0	1.1	1.3	1.8
5	50	0	20.4	11.4	7.6	4.4		8.7	5.4	3.4	2.6	4.9	5.9	9.0
5A	50	8.0-8.0	19.7	5.5	2.2	7.5		3.8	3.4	1.4	1.5	1.7	1.9	1.7
6	10-13	10-13	2.8	9.2	11.1	4.4		6.7	2.6	1.7	2.1	2.5	3.1	4.1
6A	100	10-13	1.8	4.1	2.6	3.7		2.7	2.1	1.7	1.3	1.2	1.3	1.6
7	150	0	7.2	3.5	3.5	3.3		8.2	2.5	1.6	2.2	2.4	3.4	4.1
7A	150	12-15	3.3	1.9	1.9	2.6		3.5	2.4	1.1	1.7	1.8	1.4	1.4
8	50	0	49.0	7.5	8.1	5.6		7.7	6.7	3.5	3.7	4.5	4.2	7.4
8A	50	13-16	15.7	4.9	2.8	3.6		0.8	2.0	1.6	1.6	3.8	1.5	1.3
9	100	0	2.6	8.3	4.6	2.3		2.4	2.8	2.3	3.1	4.1	3.9	5.6
9A	100	15-18	2.2	3.2	2.8	2.2		1.2	2.1	1.2	1.1	1.3	1.3	1.4
10	150	0	7.6	4.4	4.4	2.4		5.4	3.0	1.8	2.2	2.3	3.2	2.9
10A	150	20-23	2.1	3.6	2.1	2.1		0.5	2.2	1.2	1.4	1.4	1.2	1.4
STATISTICAL ANALYSIS OF THE DAILY DATA														
maximum			49.0	304.0	35.8	31.9		40.5	40.0	60.0	25.0	19.0	125.0	35.0
minimum			1.8	2.3	1.1	1.7		0.8	1.0	0.6	0.4	0.7	0.7	0.6
stan.dev.			16.5	36.6	6.1	6.0		8.9	7.0	8.4	4.1	3.4	16.6	6.4
average			14.5	13.5	5.5	5.8		6.8	4.9	3.7	2.9	3.1	5.6	4.8
skewness			+		+	+		+				+		+

**B. 2.3 MONTHLY AVERAGES OF BIOCHEMICAL OXYGEN DEMAND (mg/L)
FOR THE DARTMOUTH COVE SEWER OUTFALLS
SEPTEMBER, 1984-SEPTEMBER, 1985**

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG
Manhole														
1	Plume 1	0	16.4	23.8	27.0	16.7		121.5	51.3	83.0	116.0	39.5	48.5	93.0
2	75	0	17.4	9.9	8.2	5.2	40.9	10.2	17.9	20.3	31.8	10.9	35.3	32.3
2A	75	5.0-7.0	13.8	7.4	2.7	1.4	5.3	6.3	2.3	5.3	7.2	5.8	9.4	8.4
3	125	0	9.9	6.1	3.3	3.3	5.3	2.4	2.3	2.2	2.3	2.9	3.9	3.1
3A	125	4.5-7.0	2.4	5.2	2.6	2.2	4.5	1.8	1.8	2.1	4.8	3.2	6.4	4.9
4	Plume 2	0	11.5	9.8	17.4	19.1	26.6	11.6	11.6	14.4	19.9	6.8	3.2	2.5
5	50	0	6.7	9.0	4.6	3.4		3.0	3.0	4.0	3.9	2.5	5.6	4.0
5A	50	5.5-6.0	2.6	6.1	2.0	2.1		2.0	2.0	2.1	2.0	2.3	3.1	2.4
6	50	0	14.5	8.1	7.0	4.8	11.8	7.8	7.8	3.9	9.5	6.4	8.3	9.0
6A	50	4.0-5.0	4.3	5.0	3.6	2.9	7.7	5.3	5.3	2.4	5.3	3.5	3.9	3.3
7	50	0	16.0	9.9	6.1	7.6	6.8	2.7	2.7	3.9	7.3	7.0	7.0	8.2
7A	50	4.5-6.0	4.7	5.3	4.3	2.8	4.5	3.2	3.2	2.2	2.7	2.6	3.3	4.2
8	100	0	14.2	6.0	7.0	4.5	5.0	4.2	4.2	2.7	4.3	6.2	5.1	5.5
8A	100	3.5-7.0		4.4	2.3	2.6	2.9	1.8	1.8	1.8	2.0	2.3	3.6	2.8
9	150	0	8.3	5.5	3.5	3.4	1.7	2.8	2.8	3.0	3.8	4.3	4.0	4.5
9A	150	7.0-7.0		2.6	2.0	1.6	2.3	1.8	1.8	2.0	1.8	2.1	3.1	2.4
10	200	0					2.5	2.4	2.4	2.3	3.7	4.0	3.8	4.0
10A	200	0					2.5	1.7	1.7	1.9	1.7	2.0	3.1	2.3

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	42.0	39.0	35.8	96.0	47.5	22.0	24.5	41.0	11.0	51.0	42.5
minimum	0.3	1.9	1.1	1.0	2.0	0.0	1.4	1.0	1.4	1.4	1.6
stan.dev.	7.6	6.4	6.1	15.4	9.7	4.8	5.5	8.2	2.6	4.3	7.8
average	8.1	7.1	5.5	7.1	8.4	4.5	5.0	6.5	4.3	6.5	6.5
skewness	+	+	+	+	+	+	+	+	+	+	-

n = normal distribution

B.2.4 MONTHLY AVERAGES OF BIOCHEMICAL OXYGEN DEMAND (mg/L)
FOR THE SACKVILLE STREET OUTFALL, FEBRUARY-AUGUST, 1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FEB	MAR	APR	MAY	JUNE	JULY	AUG
Manhole			175.0	260.0	81.5		100.0	121.0	127.0
1	Plume 1	0	20.5	21.8	16.1	52.9	17.5	31.0	11.3
2	50	0	11.4	4.2	5.5	8.4	8.3	8.2	7.6
2A	50	10	4.5	2.6	1.7	2.8	3.4	3.5	1.9
3	100	0	10.1	2.4	1.9	3.2	3.2	4.6	3.0
3A	100	16	3.8	2.5	1.4	1.3	2.0	3.7	1.5
4	150	0	5.4	2.3	1.7	2.4	3.0	4.4	3.2
4A	150	19.5	2.8	2.3	1.5	1.1	1.7	3.5	1.7
5	50	0	5.2	2.9	1.8	5.7	3.8	4.6	4.1
5A	50	11	2.6	2.7	1.1	1.2	1.9	3.0	1.6
6	50	0	3.2	2.2	2.1	2.4	4.5	4.3	2.8
6A	50	10	1.8	2.8	1.7	1.0	1.8	2.7	2.3

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	20.0	23.0	20.0	124.0	20.0	42.0	12.0
minimum	1.0	1.7	0.1	0.2	0.5	0.7	1.4
stan.dev.	6.3	5.6	4.4	21.4	5.0	9.0	3.3
average	6.4	4.4	3.3	7.5	4.6	6.7	3.7
skewness	+				n	-	n

B.2.5 MONTHLY AVERAGES OF BIOCHEMICAL OXYGEN DEMAND (mg/L)
FOR THE PIER A OUTFALL, FEBRUARY-AUGUST, 1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FEB	MAR	APR	MAY	JUNE	JULY	AUG
Manhole		0	135.0	141.5	105.0		62.0	128.0	84.0
1	Plume 1	0	27.5	25.0	17.4	40.3	35.7	63.5	23.5
2	200	12	6.3	5.1	3.5	6.0	6.1	8.8	4.0
2A	200	0	2.6	2.6	1.6	2.0	3.1	3.1	1.8
3	400	17	6.0	4.1	2.4	4.3	4.4	4.9	3.1
3A	400	0	3.5	2.4	1.6	2.1	2.2	2.6	1.4
4	Plume 2	0	38.5	33.7	25.4	40.0	28.7	35.7	23.8
5	50	0	4.1	3.3	2.9	3.9	3.0	6.7	3.9
5A	50	19	2.0	2.9	1.5	1.5	1.8	3.3	1.4
6	100	0	2.7	4.9	2.1	3.3	2.7	5.3	4.1
6A	100	9	2.3	2.2	1.4	1.4	1.6	3.0	2.1

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	38.5	45.5	34.0	47.0	48.0	75.0	29.3
minimum	1.3	2.1	0.3	1.1	0.7	0.9	1.1
stan.dev.	11.7	11.2	8.8	15.6	13.1	20.7	8.2
average	9.4	8.7	5.9	11.2	8.9	13.7	6.0
skewness			-	+	+	+	+

D.3.1 MONTHLY AVERAGES OF SUSPENDED SOLIDS
(mg/L) FOR THE TUFTS CONE OUTFALL
SEPTEMBER, 1984-1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG
Manhole														
1	Plume	0	42.0	177.0	111.0	60.5		120.8	172.0	141.0	54.0	29.0	73.0	65.7
2	50	0	85.5	138.4	15.0	30.0		59.7	56.0	82.5	76.9	72.1	21.4	90.6
2A	50	1.0-3.0	5.0	13.4	19.7	35.0		36.6	31.1	26.8	32.2	14.9	21.6	15.9
3	100	0	2.0	14.6	21.7	50.0		30.8	43.5	35.1	40.3	13.6	35.6	15.4
3A	100	2.0-4.0	33.0	9.4	10.0	40.0		76.0	20.0	26.1	32.2	17.5	12.8	13.7
4	150	0	14.5	23.6	16.3	40.0		119.3	22.2	28.1	27.2	11.8	7.6	6.3
4A	150	1.0-4.0	10.5	19.8	19.0	50.0		70.0	23.1	29.5	33.1	13.9	23.8	14.9
5	50	0	13.5	33.0	35.0	47.5		18.8	26.1	24.3	26.3	11.0	8.0	10.0
5A	50	3.0-4.5	9.0	14.8	14.0	16.0		17.0	31.1	26.9	26.6	19.6	7.1	11.9
6	100	0	11.0	36.6	10.3	22.0		11.8	31.7	51.8	45.3	13.3	8.0	14.2
6A	100	2.5-4.0	9.5	24.4	12.7	27.0		20.8	34.1	71.5	33.4	17.2	8.0	10.1
7	150	0	11.0	26.2	16.3	45.5		16.8	34.0	36.4	31.6	22.2	7.3	8.2
7A	150	3.5-5.0	10.0	24.0	12.0	28.0		16.4	33.1	30.8	30.7	15.4	16.1	7.5
8	50	0	11.0	42.8	16.7	74.0		42.4	33.2	27.9	29.3	17.0	8.8	13.7
8A	50	2.5-4.0	26.5	20.8	12.3	36.5		49.2	26.3	31.5	45.2	16.3	11.7	45.5
9	100	0	22.0	25.8	33.0	32.0		29.8	31.7	34.0	21.7	17.1	7.2	8.7
9A	100	5.0-6.0	6.5	17.3	24.0	23.5		45.2	32.3	50.2	25.3	15.8	8.6	68.7
10	150	0	6.0	27.3	33.3	28.5		36.4	36.8	30.3	25.3	13.9	10.2	7.1
10A	150	4.0-7.0	34.0	19.8	24.0	22.5		33.6	30.7	32.2	26.9	17.9	10.8	7.9
								30.2	29.3	24.3	28.2	24.1	11.9	6.9

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	52.2	684.0	174.0	140.0	119.3	91.3	1272.7	127.7	136.1	35.6	187.9
minimum	2.0	3.0	1.0	2.0	11.8	10.2	20.6	16.6	4.3	7.1	4.6
stan.dev.	12.7	95.9	28.0	26.4	26.4	11.6	168.3	16.1	18.2	7.6	31.6
average	14.8	37.9	24.3	32.1	40.0	32.9	63.3	33.1	19.2	13.0	19.8
skewness	+	+	+	+	+	n	+	+	+	+	+

n = normal distribution

**B.3.2 MONTHLY AVERAGES OF SUSPENDED SOLIDS (mg/L)
FOR THE DUFFUS STREET SEWER OUTFALL
SEPTEMBER, 1984- 1985**

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG
Manhole														
1	Plume	0	28.3	34.2	32.2	27.0		49.0	64.5	30.0	48.4	41.7	100.8	27.0
2	50	0	31.0	14.8	16.0	19.0		27.3	68.4	56.9	45.4	27.0	87.7	32.7
2A	50	9-13	13.5	13.8	34.2	35.5		20.0	35.9	28.0	28.4	6.4	18.2	12.9
3	100	0	11.0	9.4	18.8	27.5		22.7	33.1	31.7	26.2	6.2	8.7	6.4
3A	100	20-23	16.0	11.0	29.0	20.5		15.5	33.1	25.5	21.7	15.0	10.3	7.0
4	150	0	34.0	29.8	28.5	25.0		9.5	34.4	30.3	25.7	18.0	11.2	6.0
4A	150	20-24	31.0	20.4	32.8	28.5		9.0	32.9	24.6	24.5	4.6	9.0	10.7
5	50	0	21.0	24.8	25.0	28.5		18.7	33.6	27.3	21.8	5.6	8.1	7.9
5A	50	6-8,0	34.0	12.2	34.3	34.5		11.3	37.1	44.1	34.2	7.4	9.5	12.7
6	100	0	42.0	11.8	18.0	20.0		13.0	30.2	25.9	26.1	6.8	14.1	7.2
6A	100	10-13	10.0	10.2	22.0	14.0		19.3	31.8	30.5	26.5	10.2	9.7	9.6
7	150	0		19.2	29.8	14.5		15.2	32.7	28.8	25.5	17.0	28.9	11.4
7A	150	12-15		25.0	37.0	26.0			31.1	25.3	25.4	17.0	9.2	8.7
8	50	0	19.0	24.0	28.8	23.5			32.5	25.3	25.7	17.8	16.4	18.2
8A	50	13-16	12.0	23.0	36.0	16.5			35.7	27.4	32.3	16.0	6.5	7.7
9	100	0	29.0	23.5	25.2	30.5			30.2	26.2	23.3	12.6	10.4	9.7
9A	100	15-18	15.0	32.8	36.2	24.0			32.0	24.7	24.1	9.4	6.1	5.5
10	150	0	28.8	16.4	33.0	21.5			32.2	27.2	25.8	11.4	8.3	8.0
10A	150	20-23	7.0	20.3	30.0	31.5			31.1	22.9	22.9	15.8	5.0	9.2

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	81.0	68.0	50.0		49.0	98.0	94.0	67.3	27.0	203.1	33.8
minimum	5.0	2.0	3.0		9.0	24.8	18.4	16.6	4.6	3.7	4.0
stan.dev.	14.3	16.7	15.8		10.5	11.1	11.1	8.0	5.1	26.3	6.9
average	21.9	21.1	23.2	24.3	18.8	34.9	29.8	26.9	11.2	14.2	10.5
skewness	+	+	-	+	+		+	+	+	+	

**B.3.3 MONTHLY AVERAGES OF SUSPENDED SOLIDS
(mg/L) FOR DARTMOUTH COVE OUTFALLS
SEPTEMBER, 1984-1985**

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG
Mailhole														
1	Plume 1	0	32.7	18.0	22.0	52.5		95.3	77.9	113.6	60.3	80.3	84.3	105.0
2	75	0	18.7	9.0	18.5	50.5		35.4	33.3	58.8	76.4	23.6	28.6	44.8
2A	75	5.0-7.0	15.3	20.0	6.0	51.0		23.5	30.5	27.0	33.3	18.1	12.6	13.5
3	125	0	10.7	13.3	28.0	52.0		22.8	36.8	30.6	39.9	12.3	11.3	10.1
3A	125	4.5-7.0	11.7	24.7	21.5	52.0		31.7	29.7	30.6	29.9	7.9	8.4	11.5
4	Plume 2	0	23.3	6.3	14.5	52.5		35.8	33.3	28.7	35.1	15.5	12.6	16.8
5	50	0	21.0	17.0	26.0	33.5		27.1	29.8	26.6	33.7	17.1	20.0	15.3
5A	50	5.5-6.0	48.0	9.7	24.5	47.5			36.6	28.7	35.8	5.4	16.3	13.7
6	50	0	22.0	17.0	17.5	50.0		32.7	33.5	31.7	47.3	15.3	21.0	15.2
6A	50	4.0-5.0	17.3	18.0	21.0	45.5		26.3	36.7	30.5	45.1	7.0	14.0	10.0
7	50	0	13.0	23.0	20.5	34.5		23.6	31.3	26.9	34.1	12.4	11.1	11.9
7A	50	4.5-6.0	10.3	19.3	45.0	44.0		28.6	37.1	33.6	37.5	9.8	10.5	7.5
8	100	0	9.0	9.3	15.5	38.0		32.2	29.9	26.1	28.3	7.6	16.7	10.4
8A	100	3.5-7.0	4.0	12.7	27.5	43.0		30.2	31.5	28.7	32.8	8.0	17.6	8.8
9	150	0	9.0	30.3	15.5	48.0		25.5	29.9	27.7	31.4	5.5	7.6	10.3
9A	150	7.0-8.0	9.0	35.8	30.0	42.5		35.8	32.2	29.5	33.0	6.3	7.6	6.4
10	200							31.7	30.1	25.3	32.9	5.9	8.8	12.1
10A	200							35.3	36.3	45.5	37.5	7.7	8.5	9.0
STATISTICAL ANALYSIS OF THE DAILY DATA														
maximum			84.0	60.0	68.0	90.0		61.7	44.6	113.3	98.8	25.6	29.3	65.9
minimum			3.0	2.0	2.0	5.0		10.0	21.4	2.0	25.8	3.8	5.4	5.6
stan.dev.			19.3	12.5	15.8	28.1		10.5	4.4	14.2	14.2	6.2	6.7	9.9
average			24.6	16.9	23.2	44.0		30.2	33.0	33.0	38.2	11.0	13.6	13.1
skewness			+	+	+	+		-	+	n	-	+	+	+

n = normal distribution

B.3.4 MONTHLY AVERAGES OF SUSPENDED SOLIDS (mg/L) FOR
THE SACKVILLE STREET OUTFALL, FEBRUARY-AUGUST, 1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FEB	MAR	APR	MAY	JUNE	JULY	AUG
Manhole			101.0	129.3	60.3		3207.0	212.0	217.4
1	Plume	0	61.2	56.8	42.0	61.9	24.8	18.9	15.0
2	50	0	10.1	31.5	27.8	29.7	14.4	10.1	12.2
2A	50	10	11.3	31.1	30.8	35.7	11.4	6.2	5.8
3	100	0	39.3	34.2	32.3	39.5	11.1	4.9	8.3
3A	100	16	39.6	34.1	27.9	24.2	10.8	8.4	7.4
4	150	0	35.8	31.9	32.0	30.7	10.5	12.2	11.6
4A	150	19.5	40.7	35.9	26.1	21.7	7.7	7.6	6.3
5	50	0	28.8	30.9	26.3	23.0	13.5	11.6	9.2
5A	50	11	41.9	32.5	31.3	28.9	10.2	8.1	5.9
6	50	0	23.3	31.9	28.6	25.6	14.3	7.4	6.5
6A	50	10	24.6	26.0	26.9	33.1	33.0	6.6	6.4

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	52.7	76.7	52.3	102.7	29.2	21.2	17.6
minimum	7.1	22.8	24.0	17.0	1.8	0.7	4.9
stan.dev.	14.8	10.6	5.6	15.6	9.4	4.8	3.6
average	28.8	34.4	30.2	32.2	12.7	9.0	8.6
skewness	-	n	-	-	+	+	+

B.3.5 MONTHLY AVERAGES OF SUSPENDED SOLIDS (mg/L)
FOR THE PIER A OUTFALL, FEBRUARY-AUGUST, 1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FEB	MAR	APR	MAY	JUNE	JULY	AUG
Manhole			72.9	86.0	57.5		90.3	79.9	42.3
1	Plume 1	0	34.4	47.6	38.1	70.7	36.5	137.6	13.0
2	200	0	35.0	32.9	24.1	26.6	16.5	16.7	8.8
2A	200	12	28.3	36.0	21.7	26.6	12.2	9.9	6.8
3	400	0	25.9	36.3	27.9	29.3	18.1	12.3	9.3
3A	400	17	34.6	32.8	22.4	22.3	12.5	21.0	4.8
4	Plume 2	0	37.2	49.5	47.6	46.6	38.3	97.5	17.6
5	50	0	30.7	32.5	27.1	28.3	17.7	14.0	7.3
5A	50	19	35.3	35.4	25.6	20.5	13.1	6.1	5.5
6	100	0	28.6	34.3	25.4	22.3	13.3	10.9	8.1
6A	100	9	31.2	34.5	27.4	27.7	13.3	7.6	6.0

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	44.4	57.7	79.2	126.0	85.6	251.3	18.6
minimum	19.7	23.8	13.2	10.0	1.2	5.1	3.4
stan.dev.	5.9	8.4	13.7	20.8	17.3	63.4	3.9
average	32.3	37.2	30.4	31.8	19.9	35.3	8.4
skewness	-	+	+	+	-	+	

**B.4.1 MONTHLY AVERAGES OF pH USING [H⁺]
FOR THE TUFTS COVE OUTFALL
SEPTEMBER, 1984-1985**

STATION	DISTANCE FROM TIE PLUME (m)	DEPTH (m)	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG
Mauhole														
1	Plume	0	8.02	7.97	7.56	7.81	6.74	7.16	7.72	7.56	7.52	7.25	6.97	6.78
2	50	0	7.96	7.94	7.84	7.72	7.37	7.37	8.30	8.15	8.18	8.29	8.57	7.24
2A	50	1.0-3.0	7.89	7.86	7.83	7.67	7.43	7.43	7.88	7.52	8.12	8.00	8.13	7.73
3	100	0	8.02	7.95	7.85	7.73	7.17	7.17	7.98	7.98	8.08	8.03	8.14	7.85
3A	100	2.0-4.0	8.01	7.91	7.84	7.72	7.46	7.46	8.00	7.98	7.99	8.03	8.34	7.90
4	150	0	7.90	7.44	7.85	7.73	6.99	6.99	7.97	7.94	7.86	7.91	7.91	7.95
4A	150	1.0-4.0	7.89	7.88	7.86	7.72	7.50	7.50	7.99	7.99	8.01	7.95	8.11	7.92
5	50	0	8.07	8.00	7.40	7.62	7.27	7.27	7.95	7.97	8.15	8.11	8.55	7.88
5A	50	3.0-4.5	8.14	7.95	7.92	7.70	7.70	7.70	7.95	7.99	8.05	8.10	8.27	7.89
6	100	0	7.95	7.95	7.91	7.71	7.66	7.66	7.91	8.00	8.16	8.16	8.52	7.90
6A	100	2.5-4.0	7.99	8.00	7.90	7.73	7.75	7.75	7.95	7.98	8.11	8.17	8.23	7.92
7	150	0	8.14	7.99	7.90	7.67	7.76	7.76	7.93	7.98	8.09	8.20	8.54	7.92
7A	150	3.5-5.0	8.12	8.05	7.90	7.75	7.78	7.78	7.98	8.00	8.14	8.14	8.22	7.92
8	50	0	8.03	8.10	7.92	7.69	8.52	8.52	7.97	8.05	8.17	8.16	8.47	7.61
8A	50	2.5-4.0	7.89	8.00	7.95	7.69	7.94	7.94	7.95	8.01	8.11	8.06	8.24	7.92
9	100	0	8.00	8.05	7.93	7.71	7.83	7.83	7.99	8.03	8.17	8.20	8.49	7.75
9A	100	5.0-6.0	7.97	8.00	7.94	7.75	7.93	7.93	8.01	8.03	8.10	8.12	8.20	7.90
10	150	0	8.12	8.06	7.93	7.74	7.91	7.91	7.99	8.01	8.14	8.27	8.59	7.80
10A	150	4.0-7.0	8.10	8.01	7.95	7.73	7.96	7.96	8.00	8.02	8.11	8.13	8.21	7.85

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum
minimum
stan.dev.
average
skewness

maximum	8.18	8.36	8.00	9.03	10.7	9.12	8.21	8.25	8.55	8.59	8.10
minimum	7.76	7.74	7.35	7.51	6.7	7.74	7.85	7.70	7.79	6.97	6.85
stan.dev.	0.12	0.13	0.11	0.23	0.7	0.18	0.08	0.10	0.16	0.36	0.21
average	8.02	8.01	7.90	7.89	9.2	8.07	8.01	8.12	8.15	8.33	7.90
skewness	n	+	-	-	-	n	+	-	n	+	n

n = normal distribution

B.4.2. MONTHLY AVERAGES OF pH USING [H⁺]
FOR THE DUFFUS STREET OUTFALL
SEPTEMBER, 1984-1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG
Manhole	Plume													
1	0		6.86	7.43	7.70	7.44		7.43	7.15	7.17	7.31	7.00	6.28	6.58
2	50	0	7.50	7.80	7.74	7.64		7.64	7.37	7.58	7.42	7.09	7.21	7.08
2A	50	9.0-13	7.43	7.90	7.11	7.75		7.91	7.96	7.95	8.03	8.06	7.96	7.50
3	100		8.11	7.92	7.83	7.81		7.98	8.00	8.00	8.06	8.12	8.13	7.94
3A	100	20-23	8.07	7.97	7.87	7.83		7.96	7.98	8.05	8.09	8.04	8.06	7.88
4	150	0	7.82	7.99	7.86	7.86		7.99	8.01	8.03	8.07	8.26	8.20	7.93
4A	150	20-24	7.88	7.99	7.87	7.85		8.07	8.02	8.06	8.09	8.02	8.06	7.91
5	50	0	7.87	7.99	7.87	7.85		7.98	7.97	7.96	8.07	8.02	8.07	7.78
5A	50	8-6.0	8.06	8.02	7.86	7.83		7.97	7.98	8.06	8.05	8.06	8.06	7.90
6	100	0	8.09	7.84	7.81	7.82		7.95	7.94	8.03	8.08	8.16	8.11	7.91
6A	100	10-13	8.11	8.04	7.86	7.83		8.02	7.95	8.06	8.08	8.06	8.06	7.89
7	150	0		8.01	7.85	7.87		7.45	7.94	8.03	8.09	8.17	8.14	7.92
7A	150	12-15		8.01	7.87	7.85		7.96	7.96	8.06	8.10	8.10	8.03	7.90
8	50	0	8.00	8.08	7.87	7.87		8.06	7.96	8.01	8.06	8.06	8.12	7.83
8A	50	13-16	8.14	8.06	7.88	7.87		7.96	7.96	8.08	8.08	8.04	8.05	7.88
9	100		8.11	8.05	7.86	7.87		7.91	7.95	8.04	8.05	8.14	8.14	7.90
9A	100	15-18	8.11	8.05	7.88	7.87			7.96	8.08	8.07	8.01	8.05	7.89
10	150	0	6.60	8.07	7.85	7.87		7.96	7.97	8.01	8.08	8.24	8.16	7.98
10A	150	20-23	6.54	8.04	7.85	7.87		7.97	7.98	8.08	8.11	8.02	8.04	7.90
STATISTICAL ANALYSIS OF THE DAILY DATA														
maximum			8.14	8.18	7.94	7.87		8.07	8.05	8.10	8.26	9.04	8.39	8.09
minimum			7.44	7.18	7.62	7.47		7.43	7.00	7.50	7.28	7.09	7.03	6.89
stan.dev.			0.23	0.17	0.07	0.08		0.15	0.14	0.12	0.18	0.28	0.23	0.23
average			8.01	8.00	7.87	7.77		7.92	8.00	8.00	8.08	8.16	8.09	7.89
skewness			-	+	-	-		n		-	-	n	+	+

n = normal distribution

**B.4.3 MONTHLY AVERAGES OF pH USING [H+]
FOR THE DARTMOUTH COVE OUTFALLS
SEPTEMBER, 1984-1985**

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG
Nanhole														
1	Plume 1	0	7.97	8.05	7.79	7.70		7.72	7.58	7.79	6.90	7.20	6.86	7.46
2	75	0	8.03	7.99	7.84	7.50		7.91	7.82	7.79	7.75	8.00	7.79	7.42
2A	75	5.0-7.0	8.11	7.99	7.89	7.79		7.94	7.95	7.88	8.00	8.09	8.03	7.71
3	125	0	7.98	8.07	7.88	7.81		7.93	7.92	7.99	8.10	8.08	7.90	7.90
3A	125	4.5-7.0	8.09	8.06	7.88	7.71		7.93	7.93	7.92	8.02	8.16	7.99	7.93
4	Plume 2	0	7.57	7.05	7.75	7.72		7.83	8.00	7.97	8.03	8.13	8.02	7.80
5	50	0	7.91	8.06	7.90	7.81			7.85	7.87	7.94	8.06	7.95	7.72
5A	50	5.5-6.0	8.06	8.07	7.41	7.85			7.99	7.99	8.10	8.14	8.09	7.96
6	50	0	8.04	8.05	7.87	7.45		7.86	7.92	7.91	7.97	8.09	7.98	8.00
6A	50	4.0-5.0	8.06	8.03	7.85	7.83		7.91	7.78	7.95	7.87	7.95	7.98	7.95
7	50	0	8.03	8.07	7.83	7.77		7.95	7.92	7.92	8.07	7.99	7.99	7.80
7A	50	4.5-6.0	8.08	8.02	7.74	7.76		7.93	7.88	8.00	8.04	8.09	8.06	7.74
8	100	0	8.04	8.04	7.87	7.80		7.93	8.00	7.94	8.03	8.07	8.08	7.97
8A	100	3.5-7.0	8.11	8.05	7.89	7.74		8.00	8.02	7.94	8.04	8.13	8.00	7.89
9	150	0	7.26	8.08	7.88	7.83		7.96	8.00	7.94	8.03	8.13	8.13	8.04
9A	150	7.0-8.0	7.26	8.08	7.88	7.83		7.96	8.03	7.98	8.09	8.12	8.07	7.96
10	200							7.95	8.00	7.97	8.10	8.16	8.15	7.99
10A	200							7.97	8.03	7.97	8.06	8.20	8.04	8.07

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum
minimum
stan.dev.
average
skewness

8.19	8.13	7.94	7.96	8.08	8.06	8.17	8.33	8.28	8.26
7.34	6.95	7.62	7.25	7.64	7.57	5.00	7.75	7.62	7.16
0.13	0.18	0.07	0.17	0.08	0.09	0.37	0.15	0.19	0.25
8.04	8.04	7.87	7.81	7.93	7.96	7.96	8.13	8.08	8.00
-	-	-	+	-	-	-	+	-	n

n = normal distribution

B.4.4 MONTHLY AVERAGES OF pH [H+] FOR THE SACKVILLE STREET OUTFALL,
FEBRUARY-AUGUST, 1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FEB	MAR	APR	MAY	JUNE	JULY	AUG
Manhole									
1	Plume	0	7.98	8.00	8.07	8.10	8.65	7.72	8.25
2	50	0	8.00	8.02	8.01	8.03	8.16	8.03	8.09
2A	50	10	8.00	8.02	8.04	8.02	8.12	8.07	8.14
3	100	0	8.01	8.01	8.02	8.05	8.15	8.11	8.23
3A	100	16	8.03	8.03	8.06	8.08	8.19	8.13	8.14
4	150	0	8.05	8.04	8.04	8.05	8.27	8.14	8.22
4A	150	19.5	8.07	8.01	8.07	8.04	8.08	8.10	8.18
5	50	0	8.04	7.98	8.05	8.04	8.20	8.08	8.20
5A	50	11	8.02	7.99	8.06	8.04	8.18	8.12	8.15
6	50	0	8.09	7.97	8.08	8.04	8.13	8.13	8.24
6A	50	10	8.07	8.00	8.08	8.04	8.11	8.15	8.15

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	8.14	8.06	8.19	8.29	8.35	8.20	8.25
minimum	7.91	7.92	7.95	7.93	7.88	7.92	8.00
stan.dev.	0.08	0.03	0.07	0.07	0.11	0.06	0.07
average	8.04	8.01	8.06	8.06	8.17	8.10	8.17
skewness	-	-	+	+	+	n	+

B.4.5 MONTHLY AVERAGES OF pH USING [H+] FOR
THE PIER A OUTFALL, FEBRUARY-AUGUST, 1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH FEB (m)	MAR	APR	MAY	JUNE	JULY	AUG	
Manhole									
1	Plume 1	0	7.97	7.51	7.50		7.20	7.29	7.08
2	200	0	8.05	7.34	7.93	7.82	7.71	7.57	8.03
2A	200	12	8.09	7.96	8.05	8.09	8.10	8.08	8.21
3	400	0	8.06	7.97	8.06	8.02	7.92	8.03	8.13
3A	400	17	8.08	7.98	8.06	8.10	8.21	8.10	8.23
4	Plume 2	0	8.00	8.07	8.01	8.17	8.17	7.90	8.15
5	50	0	7.94	7.68	7.80	7.57	7.90	7.74	8.08
5A	50	0	8.04	8.00	8.05	8.10	8.26	8.12	8.26
6	100	19	8.10	8.00	8.05	8.03	8.15	8.12	8.19
6	100	0	7.97	7.98	8.05	8.07	8.24	8.13	8.24
6A	100	9	8.03	8.01	8.04	8.02	8.14	8.14	8.21

STATISTICAL ANALYSIS OF THE DAILY DATA

maximum	8.16	8.07	8.17	8.17	8.33	8.18	8.25
minimum	7.84	6.96	7.66	7.27	7.65	7.44	7.96
stan.dev.	.09	.22	.12	.18	.20	.20	.08
average	8.04	7.96	8.02	8.03	8.12	8.02	8.14
skewness	+	+	+	-	+	-	-

B.5 MONTHLY LABORATORY DATA FOR OLAND'S (YOUNG STREET) OUTFALL,
JUNE-AUGUST, 1985

- 391 -

STATION	B.O.D. (mg/L)	C.O.D. (mg/L)	S.S. (mg/L)	P.H.	DATE
1	63.0	334.8	111.5	7.50	June, 1985
2	6.3	201.6	33.8	8.23	
2A	2.1	201.6	28.0	8.13	
3	2.0	201.6	21.8	8.23	
3A	1.9	244.8	21.2	8.13	
4	2.2	237.6	27.0	8.22	
4A	1.7	201.6	83.5	8.10	
5	2.1	237.6	7.9	8.24	
5A	2.6	216.0	4.6	8.11	
6	25.3	266.4	25.2	8.16	
6A	3.8	21.6	4.8	8.16	
7	10.8	7.2	24.8	8.22	
7A	3.2	158.4	23.2	8.09	
1	49.0	127.8	54.8	7.87	July, 1985
2	12.4	105.3	40.1	8.02	
2A	1.6	75.2	5.6	8.13	
3	2.9	45.1	4.3	8.37	
3A	0.8	60.2	10.6	8.12	
4	2.5	60.2	15.5	8.36	
4A	0.8	33.8	19.7	8.40	
5	10.5	116.6	31.4	8.22	
5A	0.6	109.0	5.8	8.05	
6	4.1	38.0	11.9	8.28	
6A	0.6	82.7	3.6	8.12	
1	17.5	113.5	10.1	7.82	Aug., 1985
2	5.2	113.5	7.0	7.86	
2A	2.1	74.5	8.0	7.72	
3	3.8	87.5	6.3	7.87	
3A	2.0	100.5	2.9	7.74	
4	3.3	61.5	4.3	7.86	
4A	2.0	100.5	6.3	7.76	
5	3.8	107.0	6.7	7.86	
5A	1.9	100.5	5.3	7.74	
6	3.9	107.0	9.3	7.78	
6A	2.0	107.0	8.5	7.75	

B.6 MONTHLY LABORATORY DATA FOR HISTORIC PROPERTIES OUTFALL,
JUNE-AUGUST, 1985

STATION	B.O.D. (mg/L)	C.O.D. (mg/L)	S.S. (mg/L)	P.H.	DATE
1	11.8	288.0	16.4	8.22	June, 1985
2	3.6	216.0	10.7	8.23	
2A	3.4	154.8	10.5	8.21	
3	3.5	158.4	12.2	8.25	
3A	3.5	158.4	13.5	8.16	
4	3.5	234.0	11.5	8.21	
4A	2.7	201.6	11.7	8.11	
5	6.0	270.0	48.7	8.21	
5A	3.5	187.2	11.0	8.19	
1	8.5	60.0	21.9	8.29	July, 1985
2	1.7	38.0	6.7	8.35	
2A	2.1	68.0	8.9	8.35	
3	1.4	53.0	6.8	8.34	
3A	0.6	102.0	10.0	8.14	
4	3.9	34.0	8.2	8.31	
4A	0.5	15.0	10.2	8.13	
5	2.1	0.0	22.8	8.36	
5A	0.5	11.0	5.0	8.11	
1	4.0	81.0	2.9	7.83	Aug., 1985
2	3.1	81.0	7.7	7.86	
2A	1.6	78.0	0.3	7.76	
3	2.8	94.0	7.0	7.86	
3A	1.8	87.5		7.77	
4	3.1	81.0		7.87	
4A	1.8	81.0	8.2	7.86	
5	2.6	84.0	4.5	7.90	
5A	1.6	90.5	5.2	7.82	

APPENDIX C

Halifax Harbour Seasonal Field Data

C.1.1.1 SEASONAL FIELD AVERAGES OF FALL FOR TUFTS COVE,
SEPTEMBER-NOVEMBER, 1984

STATION	DEPTH (m)	DISSOLVED OXYGEN (mg/L)	TEMPERATURE (°C)	SALINITY (°/‰)	CONDUCTIVITY (100 x $\mu\Omega$ /cm)
1	0	7.8			
2	0	8.4			
2	1	8.7			
2	2	8.8			
3	0	9.0			
3	1	8.8			
3	2	8.8			
3	3	8.8			
4	0	9.2			
4	1	8.9			
4	2	8.7			
4	3	8.7			
4	4	8.6			
5	0	8.4			
5	1	8.4			
5	2	8.3			
5	3	8.7			
5	4	7.0			
6	0	8.3			
6	1	8.1			
6	2	8.1			
6	3	8.0			
6	4	7.9			
7	0	7.8			
7	1	8.2			
7	2	8.0			
7	3	8.7			
7	4	8.8			
8	0	8.2			
8	1	8.5			
8	2	8.8			
8	3	9.4			
8	4	9.4			
9	0	7.8			
9	1	8.4			
9	2	8.6			
9	3	9.1			
9	4	9.3			
10	0	8.6			
10	1	8.7			
10	2	9.0			
10	3	9.2			
10	4	9.3			

C.1.2 SEASONAL FIELD AVERAGES OF WINTER FOR TUFTS COVE,
DECEMBER, 1984-FEBRUARY, 1985

- 394 -

STATION	DEPTH: (m)	DISSOLVED OXYGEN (mg/L)	TEMPERATURE (°C)	SALINITY (‰)	CONDUCTIVITY (100 x $\mu S/cm$)
1	0	9.8	1.8	27.5	
2	0	8.5	1.7	28.2	
2	1	8.4	1.7	28.0	
2	2	8.7	1.5	26.5	
3	0	9.1	2.0	27.6	
3	1	9.1	2.0	28.3	
3	2	9.5	2.0	28.4	
3	3	8.8	1.5	28.4	
4	0	8.2	2.0	27.5	
4	1	8.3	1.9	28.3	
4	2	8.8	1.9	28.7	
4	3	7.2	1.9	28.7	
4	4	8.7	1.9	27.5	
5	0	7.8	1.9	28.0	
5	1	8.3	1.6	28.5	
5	2	9.0	2.0	29.0	
5	3	9.5	1.8	29.0	
5	4	8.8	1.6	28.5	
5	5	9.6	1.5	27.3	
6	0	8.4	2.2	28.7	
6	1	8.6	2.2	28.7	
6	2	9.9	2.2	29.0	
6	3	10.1	1.8	28.7	
6	4	9.4	1.6	28.3	
6	5	8.4	1.1	27.0	
7	0	8.0	3.0	29.5	
7	1	8.8	3.0	29.5	
7	2	8.5	2.6	29.2	
7	3	8.7	2.3	29.1	
7	4	9.0	1.8	28.8	
7	5	9.2	1.5	26.0	
7	6	8.2	1.5	25.5	
8	0	8.6	2.5	29.0	
8	1	9.1	2.1	29.0	
8	2	8.6	2.4	30.0	
8	3	8.1	2.9	30.1	
8	4	8.4	2.0	29.2	
9	0	8.0	3.0	29.0	
9	1	8.6	2.5	29.1	
9	2	8.9	2.1	29.1	
10	0	7.5	2.7	29.0	
10	1	7.6	2.1	29.0	
10	2	7.6	2.0	29.7	
10	3	8.2	2.0	29.8	

C.1.3 SEASONAL FIELD AVERAGES OF SPRING FOR TUFTS COVE,
MARCH-MAY, 1985

STATION	DEPTH (m)	DISSOLVED OXYGEN (mg/L)	TEMPERATURE (°C)	SALINITY (‰)	CONDUCTIVITY (100 x $\mu\Omega/\text{cm}$)
1	0	11.1	3.5	29.1	265.4
2	0	10.1	2.8	30.7	287.8
2	1	10.4	2.8	30.7	289.7
2	2	11.4	2.4	29.0	288.9
2	3	11.2	1.3	30.0	288.5
3	0	9.2	3.0	30.9	291.1
3	1	9.6	3.0	31.2	290.6
3	2	10.2	2.5	31.4	288.8
3	3	10.6	2.2	30.3	290.5
3	4	11.7	1.0	29.0	281.0
3	5	12.8		25.0	
4	0	9.3	3.3	30.6	287.8
4	1	9.5	2.6	31.0	290.4
4	2	10.2	2.3	31.2	291.3
4	3	10.8	2.2	31.3	290.9
4	4	11.3	2.1	31.5	290.5
4	5	9.7	4.3	31.3	294.5
5	0	9.7	3.1	31.0	283.8
5	1	9.8	2.7	30.7	287.0
5	2	10.4	2.5	30.8	287.5
5	3	10.6	2.4	30.5	285.7
5	4	11.1	2.2	30.7	285.0
5	5	10.9	1.1	30.6	271.0
6	0	9.7	3.3	30.0	285.0
6	1	9.6	2.9	30.6	288.0
6	2	10.1	2.9	30.6	289.0
6	3	10.5	2.5	30.6	292.0
6	4	10.4	2.3	30.8	292.0
6	5	10.0	1.5	30.9	279.0

7	0	9.8	3.2	30.5	286.5
7	1	9.7	3.1	31.0	290.9
7	2	10.0	2.9	31.2	292.8
7	3	10.5	2.4	31.3	291.0
7	4	10.5	2.1	30.7	289.7
7	5	11.6	1.2	31.0	286.5
7	6	12.0	1.2	30.9	286.0
7	7	11.7	1.0	31.6	289.5
8	0	9.8	3.3	30.5	277.3
8	1	9.6	2.9	31.5	289.2
8	2	9.9	2.7	31.6	290.3
8	3	10.5	2.4	31.6	290.7
8	4	10.8	1.9	31.7	286.4
8	5	10.4	1.2	30.0	270.0
8	6	12.4	1.0		
8	7	11.7	1.0		
9	0	9.5	3.1	30.5	285.5
9	1	9.3	2.8	31.0	289.5
9	2	9.7	2.5	31.2	287.9
9	3	10.2	2.5	31.0	290.1
9	4	11.0	1.2	30.7	279.7
9	5	11.5	1.0	30.6	279.3
9	6	12.0	0.9	30.7	278.0
9	7	14.2	0.9		
9	8	14.4	0.9		
10	0	9.8	3.0	30.6	285.7
10	1	9.5	2.7	30.6	285.0
10	2	9.8	2.7	30.8	285.0
10	3	10.2	2.2	31.0	288.0
10	4	10.6	1.9	31.0	288.2
10	5	11.0	2.0	31.1	287.4
10	6	11.2	1.9	31.2	287.4
10	7	11.4	1.9	32.4	286.9
10	8	11.8	1.6	32.8	285.0
10	9	10.5	3.0	32.8	289.0

C.1.4 SEASONAL FIELD AVERAGES OF SUMMER FOR TUFTS COVE,
JUNE-AUGUST, 1985

STATION	DEPTH (m)	DISSOLVED OXYGEN (mg/l.)	TEMPERATURE (°C)	SALINITY (°/oo)	CONDUCTIVITY (100 x $\mu\Omega$ /cm)
1	0	7.8	11.6	24.5	285.6
2	0	7.4	12.1	26.6	312.1
2	1	7.9	10.9	28.0	318.8
2	2	7.7	9.5	29.1	317.6
2	3	8.0	6.8	29.8	323.5
2	4	8.2	6.5	29.6	299.0
3	0	7.1	11.9	25.4	298.4
3	1	7.1	10.7	26.9	304.7
3	2	7.5	8.4	28.5	300.4
3	3	7.7	7.8	28.5	298.0
3	4	8.0	6.4	29.7	303.5
4	0	6.8	12.1	25.3	291.3
4	1	6.8	11.0	27.0	307.6
4	2	7.4	8.6	28.1	300.9
4	3	7.5	8.0	27.7	299.4
4	4	8.1	6.5	29.1	296.7
5	0	8.1	12.5	26.2	311.6
5	1	8.5	13.0	26.6	307.2
5	2	8.6	9.1	28.1	304.6
5	3	8.6	8.0	28.5	300.6
5	4	7.9	6.2	29.4	291.5

cont'd

6	0	8.2	12.4	26.0	307.9
6	1	8.4	11.3	26.8	308.9
6	2	8.5	9.5	28.2	306.1
6	3	8.7	7.8	28.7	300.8
6	4	8.7	6.9	28.6	292.9
7	0	8.5	12.3	26.5	313.0
7	1	8.3	11.4	26.8	312.9
7	2	8.5	10.9	27.1	310.4
7	3	8.6	8.9	28.2	304.9
7	4	8.7	7.2	28.8	295.7
7	5	8.2	5.8	29.9	292.0
7	6	8.0	5.0	31.2	300.0
8	0	8.1	12.2	26.9	303.9
8	1	8.3	11.4	26.7	308.8
8	2	8.4	10.3	27.8	309.4
8	3	8.5	8.4	28.3	303.3
8	4	8.2	7.7	29.1	300.8
8	5	7.5	5.8	30.0	289.2
9	0	8.0	11.6	26.8	305.0
9	1	8.1	11.1	27.0	314.8
9	2	8.3	10.1	27.8	308.4
9	3	8.4	8.7	28.4	304.9
9	4	8.5	7.6	29.3	300.8
9	5	8.8	6.7	28.8	293.1
9	6	7.6	5.0	31.0	302.0
10	0	7.7	12.1	26.6	311.2
10	1	7.9	11.1	27.2	310.1
10	2	8.2	10.3	27.8	309.7
10	3	8.3	9.7	28.2	308.4
10	4	8.6	7.7	28.5	300.1
10	5	8.7	7.2	28.9	299.0
10	6	8.2	5.2	30.1	292.2
10	7	8.3	4.6	30.3	288.0

C.2.1. SEASONAL FIELD AVERAGES OF FALL FOR DUFFUS STREET,
SEPTEMBER-NOVEMBER, 1984

STATION	DEPTH (m)	DISSOLVED OXYGEN (mg/L)	TEMPERATURE (°C)	SALINITY (‰)	CONDUCTIVITY (100 x $\mu S/cm$)
1	0	8.8			
2	0	8.9			
2	1	9.1			
2	2	9.5			
2	3	9.9			
2	4	10.1			
2	5	10.3			
2	6	10.8			
2	7	11.0			
2	8	12.0			
2	9				
2	10				
3	0	9.1			
3	1	9.4			
3	2	9.6			
3	3	9.9			
3	4	10.0			
3	5	10.5			
3	6	10.7			
3	7	10.1			
3	8	10.1			
3	9	9.4			
3	10	9.6			
4	0	8.6			
4	1	9.0			
4	2	10.0			
4	3	10.2			
4	4	10.3			
4	5	10.6			
4	6	10.7			
4	7	10.8			
4	8	11.2			
4	9	11.3			
4	10	9.5			
5	0	7.9			
5	1	8.8			
5	2	9.3			
5	3	9.8			
5	4	10.2			
5	5	10.5			
5	6	8.6			
5	7	10.7			
5	8	11.1			

cont'd

6	0	8.5
6	1	8.2
6	2	8.5
6	3	8.9
6	4	9.2
6	5	9.4
6	6	9.5
6	7	9.7
6	8	9.9
6	9	10.1
6	10	10.5
7	0	8.9
7	1	8.4
7	2	8.4
7	3	9.0
7	4	9.2
7	5	9.4
7	6	9.5
7	7	9.7
7	8	9.8
7	9	10.4
7	10	8.2
8	0	8.5
8	1	8.2
8	2	8.3
8	3	8.5
8	4	8.8
8	5	8.1
8	6	9.1
8	7	9.2
8	8	9.3
8	9	9.5
8	10	9.4
9	0	8.4
9	1	8.4
9	2	8.1
9	3	8.4
9	4	8.5
9	5	9.1
9	6	9.3
9	7	9.4
9	8	9.6
9	9	9.6
9	10	9.6
10	0	8.7
10	1	8.0
10	2	8.2
10	3	8.7
10	4	9.0
10	5	11.4
10	6	9.3
10	7	9.4
10	8	9.6
10	9	9.5
10	10	9.4

C.2.2 SEASONAL FIELD AVERAGES OF WINTER FOR DUFFUS STREET,
DECEMBER, 1984-FEBRUARY, 1985

STATION	DEPTH (m)	DISSOLVED OXYGEN (mg/l.)	TEMPERATURE (°C)	SALINITY (‰)	CONDUCTIVITY (100 x $\mu\Omega$ /cm)
1	0	9.5	2.0	25.5	
2	0	9.9	0.7	29.7	
2	1	10.1	0.5	30.0	
2	2	10.5	0.3	30.0	
2	3	10.6	0.2	30.0	
2	4	10.6	0.3	30.0	
2	5	11.2	0.3	30.0	
2	6	11.4	0.2	30.1	
2	7	11.5	0.2	30.2	
2	8				
2	9				
2	10				
3	0	10.0	0.9	29.8	
3	1	10.2	0.5	29.9	
3	2	10.3	0.4	29.9	
3	3	10.7	0.4	29.9	
3	4	10.9	0.4	29.9	
3	5	11.1	0.4	29.9	
3	6	11.2	0.4	30.0	
3	7	11.3	0.4	30.0	
3	8	11.5	0.4	30.0	
3	9	12.0	0.5	30.1	
3	10	11.9	0.5	30.1	
4	0	11.2	0.7	29.1	
4	1	10.7	0.7	29.4	
4	2	10.8	0.8	29.5	
4	3	10.7	0.8	29.9	
4	4	11.1	0.8	30.0	
4	5	11.1	0.8	30.0	
4	6	11.3	0.7	30.0	
4	7	11.3	0.7	30.0	
4	8	11.3	0.7	30.0	
4	9	11.2	0.7	30.0	
4	10	10.2	0.8	30.0	
5	0	9.4	1.1	28.5	
5	1	9.6	1.0	29.0	
5	2	10.2	0.9	29.7	
5	3	10.5	0.9	29.8	
5	4	10.5	0.8	29.8	
5	5	10.7	0.8	29.8	
5	6	10.6	0.8	29.9	
5	7	8.5	0.7	30.0	
5	8				

cont'd

28.5
29.0
29.1
29.6
29.8
30.0
30.0
30.0
30.0
30.0
30.0
28.6
29.1
29.3
29.8
29.9
29.9
30.0
30.0
30.0
30.0
30.0
27.2
29.0
29.1
29.2
29.5
29.6
29.6
29.7
29.9
29.9

1.3
1.1
1.0
1.0
0.9
0.9
0.8
0.8
0.8
0.8
0.7
1.8
1.2
1.0
0.9
0.9
0.8
0.8
0.9
0.9
0.9
0.9
2.0
1.3
1.1
1.0
1.0
1.0
1.0
1.0
1.0
1.0
1.0
1.0

10.0
10.1
9.9
10.0
10.2
10.8
10.9
11.0
11.5
11.7
8.7
9.8
9.7
9.8
9.9
10.3
10.7
10.7
11.2
11.1
11.3
11.3
9.9
9.9
10.1
10.4
10.5
10.6
10.8
11.0
11.1
11.2
11.5
10.0
9.8
10.0
10.4
10.4
10.5
10.5
10.1
10.2
10.6
9.9
10.3
9.8
9.8
9.7
10.0
9.7
10.0
10.3
10.4
10.1
10.1

0
1
2
3
4
5
6
7
8
9
10
0
1
2
3
4
5
6
7
8
9
10
0
1
2
3
4
5
6
7
8
9
10
0
1
2
3
4
5
6
7
8
9
10
0
1
2
3
4
5
6
7
8
9
10
0
1
2
3
4
5
6
7
8
9
10

6
6
6
6
6
6
6
6
6
6
6
7
7
7
7
7
7
7
7
7
7
7
8
8
8
8
8
8
8
8
8
8
9
9
9
9
9
9
9
9
9
10
10
10
10
10
10
10
10
10
10
10

29.2
29.2
28.3
28.8
29.0
29.0
29.0
29.0
29.0
29.0
29.2
29.2
29.2

1.0
0.9
1.5
1.5
1.0
1.0
1.0
1.0
1.0
1.0
1.0
1.0
1.0

C.2.3 SEASONAL FIELD AVERAGES OF SPRING FOR INIFUS STREET,
MARCH-MAY, 1985.

STATION	DEPTH (m)	DISSOLVED OXYGEN (mg/l.)	TEMPERATURE (°C)	SALINITY (σ_{t00})	CONDUCTIVITY ($100 \times \mu \Omega / \text{cm}$)
1	0	10.5	4.1	22.0	210.0
2	0	10.2	2.6	30.0	269.9
2	1	10.8	2.1	32.3	284.3
2	2	11.5	1.9	32.0	284.2
2	3	12.1	1.8	32.2	284.6
2	4	12.6	1.5	32.2	283.7
2	5	12.9	1.4	32.5	283.5
2	6	13.2	1.4	32.5	283.6
2	7	13.2	1.3	32.5	282.9
2	8	13.6	1.3	32.5	282.9
2	9	13.5	1.2	32.6	281.9
2	10	13.5	1.1	32.6	282.2
3	0	10.9	2.6	30.4	276.3
3	1	10.6	2.6	31.5	280.0
3	2	11.2	2.3	31.7	282.9
3	3	11.7	2.0	31.8	283.1
3	4	12.2	1.9	32.1	282.1
3	5	12.5	1.7	32.1	282.1
3	6	12.9	1.5	32.3	281.2
3	7	13.1	1.5	32.5	281.3
3	8	13.2	1.4	32.6	282.3
3	9	13.3	1.4	32.6	282.3
3	10	13.4	1.4	32.5	282.2
4	0	10.8	2.7	30.8	275.9
4	1	10.5	2.5	31.4	280.6
4	2	11.0	2.4	31.7	280.5
4	3	11.4	2.0	31.9	280.0
4	4	11.9	1.7	32.2	279.2
4	5	12.2	1.6	32.2	278.8
4	6	12.6	1.6	32.3	279.6
4	7	12.7	1.5	32.3	281.0
4	8	12.9	1.5	32.5	278.9
4	9	13.1	1.4	32.5	280.5
4	10	13.2	1.3	32.5	280.2
5	0	10.5	3.1	29.4	264.6
5	1	10.2	2.8	30.9	278.6
5	2	10.7	2.5	31.2	279.7
5	3	11.2	2.3	31.4	279.3
5	4	11.7	2.0	31.6	279.7
5	5	12.0	1.8	31.8	278.8
5	6	12.3	1.7	32.1	278.0
5	7	12.5	2.0	32.2	278.9
5	8	12.6	1.5	32.2	280.3
5	9	12.9	1.6	32.5	285.4
5	10	12.5	1.6	33.1	285.6

cont'd

6	0	10.8	2.9	31.2	275.8
6	1	10.5	2.7	31.3	279.0
6	2	10.5	2.5	31.4	277.5
6	3	11.1	2.5	31.5	278.5
6	4	11.6	2.0	31.7	279.0
6	5	12.0	1.8	31.7	277.2
6	6	12.2	1.7	31.8	277.2
6	7	12.3	1.6	31.9	277.0
6	8	12.6	1.5	32.1	277.4
6	9	12.8	1.3	32.0	275.4
6	10	12.9	1.3	31.9	275.9
7	0	10.9	2.9	30.6	275.7
7	1	10.5	2.7	31.1	278.8
7	2	10.8	2.6	31.3	280.3
7	3	11.2	2.3	31.5	280.0
7	4	11.5	2.0	31.8	280.7
7	5	11.7	1.8	32.2	280.1
7	6	11.9	1.8	32.1	280.4
7	7	12.0	1.7	32.1	280.3
7	8	12.2	1.6	32.2	280.3
7	9	12.3	1.5	32.2	280.0
7	10	12.1	1.3	32.3	278.3
8	0	10.6	3.0	29.9	266.7
8	1	10.2	2.8	30.8	276.2
8	2	10.5	2.4	31.4	278.8
8	3	10.8	2.2	31.6	279.2
8	4	11.1	2.1	31.6	278.8
8	5	11.5	1.9	31.8	278.9
8	6	11.9	1.7	32.0	278.5
8	7	12.1	1.6	32.0	278.7
8	8	12.1	1.5	32.1	278.3
8	9	12.5	1.5	32.1	278.1
8	10	12.7	1.5	32.1	277.9
9	0	10.9	3.1	30.0	269.8
9	1	10.2	2.8	30.9	277.2
9	2	10.2	2.5	31.5	277.8
9	3	10.6	2.2	31.7	278.9
9	4	11.0	2.0	31.8	278.7
9	5	11.5	1.8	31.9	277.9
9	6	11.8	1.7	32.1	277.4
9	7	12.1	1.7	32.0	277.4
9	8	12.2	1.6	32.1	277.3
9	9	12.3	1.6	32.1	277.3
9	10	12.5	1.5	32.0	278.5
10	0	10.7	3.0	30.7	275.1
10	1	10.4	2.7	31.1	278.9
10	2	10.4	2.5	31.3	279.0
10	3	10.6	2.2	31.7	278.9
10	4	10.9	2.0	31.8	277.8
10	5	11.2	1.8	32.0	277.7
10	6	11.7	1.7	32.0	277.2
10	7	11.9	1.6	32.1	277.9
10	8	12.2	1.5	32.2	277.8
10	9	12.2	1.5	32.1	277.5
10	10	12.2	1.4	32.2	277.3

C.2.4 SEASONAL FIELD AVERAGES OF SUMMER FOR DUFFUS STREET,
JUNE-AUGUST, 1985

STATION	DEPTH (m)	DISSOLVED OXYGEN (mg/L)	TEMPERATURE (°C)	SALINITY (‰)	CONDUCTIVITY (100 x $\mu\Omega$ /cm)
1	0	6.8	11.5	19.1	220.2
2	0	7.7	10.8	26.3	294.6
2	1	8.1	10.1	28.2	308.2
2	2	8.6	9.3	28.6	312.7
2	3	8.9	8.6	29.0	310.4
2	4	9.2	8.2	29.2	308.4
2	5	9.3	8.0	29.1	307.3
2	6	9.3	7.3	29.5	305.2
2	7	9.3	7.0	29.4	304.3
2	8	9.1	6.6	29.6	297.0
2	9	9.1	6.4	29.6	297.3
2	10	9.7	5.5	29.8	292.9
3	0	7.9	10.9	27.0	307.6
3	1	8.1	10.8	27.6	312.5
3	2	8.4	9.8	28.3	313.0
3	3	8.6	9.1	28.5	307.7
3	4	8.9	8.6	28.7	307.0
3	5	9.1	8.1	28.7	302.4
3	6	9.2	7.5	29.5	303.0
3	7	9.3	7.1	29.6	301.6
3	8	9.4	6.7	29.8	300.7
3	9	9.4	6.2	29.9	299.1
3	10	9.4	6.0	30.0	297.4
4	0	7.9	11.8	26.8	307.4
4	1	8.1	10.9	27.6	312.2
4	2	8.3	10.1	27.9	311.9
4	3	8.5	9.0	28.6	307.2
4	4	8.7	8.5	28.9	305.8
4	5	8.9	7.7	29.3	302.7
4	6	8.9	7.5	29.4	301.8
4	7	9.0	7.2	29.4	299.3
4	8	9.0	7.0	29.5	299.6
4	9	9.1	6.8	29.5	302.2
4	10	9.0	6.3	29.5	294.9
5	0	7.3	10.8	25.8	305.0
5	1	7.5	10.5	27.3	308.9
5	2	7.6	10.1	27.5	308.8
5	3	8.1	8.7	28.5	304.6
5	4	8.4	8.2	28.9	305.5
5	5	8.6	7.7	28.6	298.4
5	6	8.7	7.4	29.0	299.3
5	7	8.7	6.9	29.0	293.9
5	8	8.8	6.1	29.2	289.8
5	9	8.8	5.8	29.7	291.5
5	10	8.7	5.2	29.1	287.2

cont'd

6	0	7.7	11.2	26.6	307.9
6	1	7.7	10.2	27.6	308.3
6	2	7.9	9.0	28.4	307.2
6	3	8.1	8.7	28.6	305.7
6	4	8.2	8.2	28.9	305.1
6	5	8.5	7.6	29.1	301.9
6	6	8.6	7.2	29.0	298.3
6	7	8.6	6.6	29.3	296.3
6	8	8.6	6.2	29.7	294.4
6	9	8.6	5.6	29.7	293.4
6	10	8.5	5.3	29.9	290.2
7	0	7.8	11.5	26.5	306.3
7	1	7.8	10.4	27.3	308.5
7	2	7.9	9.6	28.0	308.7
7	3	8.1	8.7	28.5	306.2
7	4	8.3	8.3	28.6	303.2
7	5	8.4	7.9	29.1	303.3
7	6	8.5	7.4	29.1	311.8
7	7	8.5	7.1	29.3	299.8
7	8	8.6	6.3	29.6	295.1
7	9	8.6	5.7	29.9	294.3
7	10	8.3	5.8	30.6	296.0
8	0	7.4	10.9	26.4	303.4
8	1	7.5	10.3	28.0	308.7
8	2	7.7	9.5	27.3	308.1
8	3	7.9	8.7	28.5	305.5
8	4	8.1	8.0	28.8	303.2
8	5	8.3	7.4	29.1	301.4
8	6	8.3	7.2	29.3	299.6
8	7	8.4	6.8	29.3	298.6
8	8	8.4	6.3	29.7	296.9
8	9	8.4	5.8	29.9	295.7
8	10	8.3	5.6	30.4	291.6
9	0	7.4	11.3	26.7	304.2
9	1	7.5	10.9	27.3	309.7
9	2	7.6	9.9	28.1	309.8
9	3	8.0	9.0	28.6	308.3
9	4	8.1	8.5	28.7	305.8
9	5	8.2	7.8	29.3	303.9
9	6	8.3	7.6	29.6	306.2
9	7	8.3	7.2	29.7	305.3
9	8	8.3	6.7	29.9	302.6
9	9	8.3	6.4	29.9	300.8
9	10	8.3	5.6	30.2	297.6
10	0	7.6	11.9	27.3	312.0
10	1	7.7	11.3	27.4	315.2
10	2	7.8	10.3	28.0	313.1
10	3	8.0	9.1	28.6	309.1
10	4	8.1	8.4	28.8	306.4
10	5	8.2	7.9	29.0	303.8
10	6	8.2	7.4	29.1	301.4
10	7	8.3	7.0	29.4	298.9
10	8	8.2	6.7	29.5	298.0
10	9	8.3	6.5	29.4	299.6
10	10	8.3	5.6	30.0	295.0

C.3.1.1 SEASONAL FIELD AVERAGES OF FALL FOR DARTMOUTH COVE,
SEPTEMBER-NOVEMBER, 1984

STATION	DEPTH (m)	DISSOLVED OXYGEN (mg/L)	TEMPERATURE (°C)	SALINITY (‰)	CONDUCTIVITY (100 x $\mu\Omega$ /cm)
1	0	7.5			
2	0	7.0			
2	1	7.4			
2	2	7.4			
2	3	7.5			
2	4	7.9			
2	5	7.7			
2	0	8.6			
3	1	8.3			
3	2	8.5			
3	3	8.6			
3	4	9.0			
3	5	9.3			
3	6	8.4			
4	0	9.2			
4	0	8.3			
5	1	8.2			
5	2	8.4			
5	3	8.7			
5	4	8.8			
5	5	8.8			
5	0	7.4			
6	1	7.2			
6	2	7.5			
6	3	7.7			
6	4	7.7			
7	0	7.5			
7	1	7.6			
7	2	7.5			
7	3	7.7			
7	4	7.5			
7	5	7.7			
7	0	8.0			
8	0	7.8			
8	1	8.0			
8	2	7.5			
8	3	7.6			
8	4	7.6			
8	5	7.2			
8	6	7.0			
8	7	7.4			
8	8	6.9			
9	0	7.3			
9	1	7.1			
9	2	7.5			
9	3	7.7			
9	4	8.1			
9	5	7.8			
9	6	8.3			

C.3.2 SEASONAL FIELD AVERAGES OF WINTER FOR DARTMOUTH COVE,
DECEMBER, 1984-FEBRUARY, 1985

STATION	DEPTH (m)	DISSOLVED OXYGEN (mg/L)	TEMPERATURE (°C)	SALINITY (°/∞)	CONDUCTIVITY (100 x $\mu S/cm$)
1	0	8.9	1.5	25.0	
2	0	10.0	0.8	27.8	
2	1	9.3	0.5	29.8	
2	2	9.5	0.4	30.0	
2	3	9.6	0.4	30.0	
3	0	9.1	0.6	27.6	
3	1	10.4	0.6	28.4	
3	2	10.4	0.5	29.9	
3	3	10.7	0.5	29.9	
3	4	11.1	0.5	30.0	
3	5	11.0	0.4	31.0	
3	6	11.9			
3	7	10.9			
4	0	8.8	0.6	25.0	
5	0	9.2	0.5	27.2	
5	1	9.3	0.5	28.2	
5	2	9.7	0.6	29.2	
5	3	9.9	0.6	29.9	
5	4	10.1	0.6	30.0	
5	5	10.6	0.6	30.0	
5	6	10.5	0.5	30.0	

cont'd

5	7	10.1	1.0	25.8
6	0	8.2	0.8	29.2
6	1	8.4	0.7	29.5
6	2	8.7	0.8	29.8
6	3	9.3	0.8	29.7
6	4	7.9		
6	5	7.7	1.2	26.4
7	0	8.1	0.8	28.6
7	1	8.6	0.8	28.9
7	2	8.9	0.8	29.6
7	3	9.3	0.8	29.7
7	4	9.5	0.5	30.5
7	5	9.1	0.4	30.4
7	6	8.1	1.0	28.5
8	0	8.4	1.0	28.7
8	1	8.7	1.0	29.4
8	2	9.0	0.9	29.5
8	3	9.3	0.8	29.5
8	4	9.6	0.8	29.7
8	5	9.9	0.4	30.2
8	6	8.6		
8	7	8.4	1.0	28.2
9	0	8.0	1.0	29.3
9	1	8.2	1.0	29.3
9	2	8.8	1.0	29.4
9	3	9.3	1.0	29.4
9	4	9.7	1.0	29.4
9	5	10.0	1.0	29.6
9	6	9.2	1.2	29.5
9	7	7.0	1.5	29.0
9	8	8.4	1.0	27.0
10	0	7.9	1.0	28.0
10	1	8.1	1.1	29.3
10	2	8.8	1.1	29.4
10	4	9.0	1.1	29.4
10	5	9.2	1.0	29.4
10	6	9.1	1.0	29.4
10	7	9.7	1.1	29.5
10	8	9.0	1.5	29.0
10	9			

C.3.3 SEASONAL FIELD AVERAGES OF SPRING FOR DARTMOUTH COVE,
MARCH, 1985-MAY, 1985

STATION	DEPTH (m)	DISSOLVED OXYGEN (mg/L)	TEMPERATURE (°C)	SALINITY (‰/‰)	CONDUCTIVITY (100 x $\mu\Omega$ /cm)
1	0	10.4	4.0	25.0	225.3
2	0	9.9	3.6	27.0	244.7
2	1	10.3	3.2	30.8	284.3
2	2	11.2	2.7	31.8	290.0
2	3	11.6	2.3	32.1	290.0
2	4	11.9	2.2	32.2	289.0
2	5	13.6	1.8	32.6	294.5
3	0	10.5	3.5	28.2	274.0
3	1	10.2	3.0	31.0	283.7
3	2	11.1	2.7	32.2	291.3
3	3	12.1	2.3	32.2	290.7
3	4	12.1	2.1	32.5	290.3
3	5	12.1	1.9	32.4	289.0
3	6	12.2	1.8	32.4	288.7
4	0	10.3	4.1	25.9	248.0
5	0	10.2	3.6	29.9	277.0
5	1	10.2	2.9	31.5	286.0
5	2	11.0	2.7	31.5	288.7
5	3	11.6	2.4	32.2	291.3
5	4	12.1	2.1	32.3	290.3
5	5	12.6	2.1	32.4	290.3
					cont'd

5	6	11.9	1.3	32.4	288.7
5	7	11.1	2.2	33.7	300.5
6	0	9.7	3.9	27.3	244.0
6	1	9.9	3.3	31.0	273.3
6	2	10.4	3.0	31.6	290.0
6	3	10.6	2.3	32.0	291.0
6	4	10.5	2.2	32.1	289.7
6	0	9.6	3.7	27.4	258.0
7	1	9.7	3.1	30.7	284.3
7	2	10.2	2.6	31.8	290.3
7	3	11.0	2.3	32.0	290.7
7	4	11.1	2.1	32.2	290.0
7	5	11.4	1.9	32.2	288.7
7	6	10.6	1.9	32.0	287.0
7	0	10.0	3.5	28.8	266.0
8	1	9.8	3.0	31.1	286.7
8	2	10.2	2.6	31.6	289.0
8	3	10.8	2.2	32.1	290.0
8	4	11.3	2.1	32.1	276.3
8	5	11.5	1.9	32.2	288.3
8	6	11.6	1.7	31.9	284.0
8	7	12.1	1.8	32.2	285.5
9	0	9.8	3.8	27.5	259.7
9	1	9.5	3.1	31.1	282.7
9	2	9.9	2.9	31.7	288.7
9	3	10.4	2.8	32.0	288.0
9	4	10.9	1.7	32.0	288.7
9	5	11.4	1.9	32.2	287.0
9	6	11.6	1.8	32.2	287.0
9	7	12.0	1.6	32.7	288.7
10	0	10.9	3.5	28.8	271.0
10	1	10.1	2.6	31.3	286.3
10	2	10.4	2.7	31.6	288.7
10	3	11.0	2.5	31.8	288.3
10	4	11.5	2.3	32.1	288.7
10	5	11.8	2.2	32.0	289.0

C.3.4 SEASONAL FIELD AVERAGES OF SUMMER FOR DARTMOUTH COVE,
JUNE-AUGUST, 1985

STATION	DEPTH (m)	DISSOLVED OXYGEN (mg/L)	TEMPERATURE (°C)	SALINITY (‰)	CONDUCTIVITY (100 x $\mu S/cm$)
1	0	8.3	11.8	26.8	287.3
2	0	7.8	13.0	24.9	314.3
2	1	8.3	12.5	27.3	314.0
2	2	8.4	9.4	29.5	320.0
2	3	8.5	8.5	29.8	315.0
2	4	7.8	8.2	29.9	314.7
3	0	7.9	12.8	24.9	294.3
3	1	8.5	10.4	28.3	321.3
3	2	8.8	9.6	29.4	321.3
3	3	9.0	8.4	29.2	314.3
3	4	8.7	7.9	29.8	312.0
3	5	8.6	7.6	30.8	316.5
4	0	8.4	12.0	24.0	285.0
5	0	8.1	13.1	24.9	301.3
5	1	8.2	11.1	28.1	317.0
5	2	8.9	9.4	29.4	320.0
5	3	9.2	8.5	30.3	315.0
5	4	9.2	7.9	30.2	312.7
5	5	9.0	7.6	30.3	310.7
5	6	8.1	8.0	30.0	299.0
6	0	7.9	12.2	25.5	309.3
					cont'd

6	1	8.1	10.8	28.4	306.7
6	2	8.3	8.8	30.1	326.3
6	3	8.2	8.4	30.5	324.7
6	4	6.5	8.1	29.4	323.0
7	0	7.9	13.1	25.9	300.3
7	1	8.4	10.9	28.7	327.3
7	2	8.6	10.1	29.7	331.3
7	3	8.8	8.6	30.1	326.3
7	4	8.6	8.0	30.4	322.7
7	5	8.7	7.6	27.8	320.7
7	6	7.1	7.3	31.3	322.5
8	0	7.6	13.5	24.6	293.3
8	1	8.2	11.6	28.6	323.3
8	2	8.6	10.0	29.7	328.7
8	3	8.7	8.3	30.4	321.7
8	4	8.8	7.9	30.8	320.0
8	5	8.8	7.7	30.8	318.7
8	6	8.6	7.4	30.9	314.3
8	7	6.2	6.8	31.6	320.0
9	0	7.6	13.0	26.6	308.7
9	1	8.5	10.6	28.9	321.7
9	2	8.7	9.3	29.9	325.0
9	3	8.6	8.2	30.4	320.0
9	4	8.6	7.9	30.5	318.7
9	5	8.7	7.5	30.8	318.0
9	6	8.5	7.4	30.7	315.7
9	7	7.8	6.8	31.7	319.0
10	0	7.7	13.2	25.8	304.7
10	1	8.4	11.3	28.7	324.3
10	2	8.8	10.0	29.6	329.7
10	3	8.9	8.4	30.2	321.0
10	4	8.9	7.9	30.2	318.0
10	5	8.9	7.8	30.4	318.0
10	6	9.0	7.4	30.7	316.3
10	7	8.7	7.0	30.7	313.7

C.4.2 SEASONAL FIELD AVERAGES OF WINTER FOR SACKVILLE STREET,
FEBRUARY, 1985.

STATION	DEPTH (m)	DISSOLVED OXYGEN (mg/L)	TEMPERATURE (°C)	SALINITY (‰)	CONDUCTIVITY (100 x $\mu S/cm$)
1	0	10.7	1.1	26.4	315.0
2	0	10.0	0.5	28.4	360.0
2	1	10.2	0.5	29.0	380.0
2	2	10.4	0.5	29.2	380.0
2	3	11.0	0.5	29.2	380.0
2	4	11.2	0.5	29.3	380.0
2	5	10.8	0.5	29.5	380.0
2	6	11.4	0.5	29.5	380.0
2	7	11.3	0.0	29.7	380.0
2	8	11.5	0.0	28.7	370.0
2	9	11.5	0.0	28.7	370.0
2	10	11.8	0.0	28.7	370.0
3	0	10.6	0.5	28.8	370.0
3	1	10.2	0.5	29.2	377.0
3	2	10.5	0.5	29.3	379.0
3	3	10.7	0.5	29.3	379.0
3	4	11.0	0.5	29.3	379.0
3	5	11.3	0.5	29.5	379.0
3	6	11.5	0.5	29.5	380.0
3	7	11.8	0.3	29.5	379.0
3	8	11.9	0.3	29.5	379.0
					cont'd

3	9	12.0	0.3	29.5	379.0
3	10	12.7	0.3	29.5	379.0
4	0	11.0	0.5	28.8	375.0
4	1	10.2	0.5	29.0	376.0
4	2	10.2	0.5	29.2	378.0
4	3	10.3	0.5	29.2	378.0
4	4	10.8	0.5	29.3	379.0
4	5	11.1	0.5	29.4	378.0
4	6	11.4	0.5	29.4	378.0
4	7	11.7	0.5	29.5	378.0
4	8	11.9	0.3	29.5	377.0
4	9	12.3	0.3	29.4	378.0
4	10	12.3	0.3	29.4	378.0
5	0	10.4	0.5	28.9	370.0
5	1	9.5	0.5	29.0	375.0
5	2	9.5	0.5	29.3	380.0
5	3	9.8	0.5	29.3	380.0
5	4	10.6	0.5	29.6	381.0
5	5	10.9	0.5	29.6	381.0
5	6	11.2	0.5	29.6	381.0
5	7	11.5	0.5	29.6	381.0
5	8	11.7	0.5	29.6	381.0
5	9	12.0	0.5	29.6	381.0
5	10	12.2	0.5	29.5	380.0
6	0	10.0	0.5	26.5	378.0
6	1	9.4	0.5	29.3	379.0
6	2	9.3	0.5	29.3	380.0
6	3	9.8	0.5	29.3	380.0
6	4	10.0	0.5	29.3	380.0
6	5	10.6	0.5	29.3	381.0
6	6	11.0	0.5	29.3	380.0
6	7	11.4	0.5	29.4	380.0
6	8	11.6	0.5	29.5	380.0
6	9	11.8	0.5	29.4	380.0
6	10	11.9	0.5	29.5	380.0

C.4.3 SEASONAL FIELD AVERAGES OF SPRING FOR SACKVILLE STREET,
MARCH-MAY, 1985.

STATION	DEPTH (m)	DISSOLVED OXYGEN (mg/l.)	TEMPERATURE (°C)	SALINITY (°/∞)	CONDUCTIVITY (100 x μ S /cm)
1	0	9.9	4.3	27.2	253.3
2	0	9.7	2.7	30.8	277.8
2	1	10.6	2.5	31.7	283.1
2	2	11.1	2.3	32.0	283.0
2	3	12.0	2.2	32.1	282.9
2	4	12.3	1.9	32.1	283.3
2	5	12.7	1.7	32.4	282.5
2	6	12.8	1.6	32.5	282.1
2	7	13.0	1.4	32.5	281.1
2	8	13.1	1.2	32.6	280.6
2	9	12.8	1.2	32.5	280.3
2	10	12.3	1.2	33.4	284.7
3	0	10.7	2.9	31.6	283.4
3	1	10.4	2.5	32.0	284.5
3	2	11.1	2.4	32.0	283.3
3	3	11.7	2.4	32.1	282.9
3	4	12.0	2.1	32.1	283.1
3	5	12.4	1.8	32.2	282.2
3	6	12.6	1.7	32.4	281.8
3	7	12.9	1.5	32.5	280.6
3	8	13.0	1.3	32.6	280.2
					cont'd

3	9	13.0	1.2	32.6	280.6
3	10	13.1	0.9	32.7	281.2
4	0	10.7	2.8	31.4	282.9
4	1	10.5	2.6	31.7	284.1
4	2	10.9	2.4	31.8	283.3
4	3	11.4	2.2	31.9	283.2
4	4	12.0	2.0	32.0	282.7
4	5	12.2	1.9	32.0	281.5
4	6	12.5	1.7	31.3	280.0
4	7	12.6	1.7	32.3	280.1
4	8	12.5	1.5	32.3	280.2
4	9	12.9	1.4	32.5	280.2
4	10	13.0	1.3	32.5	280.8
4	0	11.4	1.2	31.8	271.2
5	1	10.5	1.1	31.9	273.2
5	2	11.2	1.1	31.7	273.0
5	3	11.8	1.0	31.9	273.2
5	4	12.4	1.0	32.0	273.7
5	5	12.8	1.0	31.9	274.0
5	6	13.1	1.0	32.0	273.8
5	7	13.3	1.0	31.9	274.0
5	8	13.5	0.9	32.1	274.3
5	9	13.6	0.9	32.1	275.0
5	10	13.4	0.8	32.3	275.0
6	0	10.9	1.2	32.0	272.7
6	1	10.3	1.2	32.0	273.7
6	2	11.1	1.2	32.1	274.3
6	3	11.7	1.1	32.1	274.2
6	4	12.2	1.1	32.2	275.2
6	5	12.9	1.1	32.1	275.2
6	6	13.2	1.1	32.2	275.2
6	7	13.2	1.0	32.2	275.0
6	8	13.6	1.0	32.4	276.5
6	9	13.9	0.9	32.4	276.4
6	10	13.9	0.9	32.5	276.5

C.4.4 SEASONAL FIELD AVERAGES OF SUMMER FOR SACKVILLE STREET,
JUNE-AUGUST, 1985.

STATION	DEPTH (m)	DISSOLVED OXYGEN (mg/L)	TEMPERATURE (°C)	SALINITY (°/∞)	CONDUCTIVITY (100 x μ S /cm)
1	0	8.4	11.4	25.6	295.8
2	0	7.8	11.1	27.4	313.4
2	1	8.0	10.5	28.1	318.9
2	2	8.3	9.5	28.7	318.4
2	3	8.5	8.8	29.5	318.9
2	4	8.6	8.4	29.9	320.5
2	5	8.8	7.8	30.3	317.6
2	6	8.8	7.4	30.4	314.7
2	7	8.8	7.2	30.5	314.1
2	8	9.3	6.3	30.0	301.7
2	9	9.5	5.2	29.8	289.5
2	10	9.4	4.9	30.0	290.0
3	0	8.3	11.0	27.5	315.5
3	1	8.4	10.7	28.2	316.8
3	2	8.6	10.3	28.6	314.2
3	3	8.8	9.1	29.0	312.0
3	4	8.9	8.7	29.2	310.5
3	5	9.0	8.2	29.6	308.3
3	6	9.1	7.6	29.9	307.0
3	7	9.1	7.4	29.9	305.8
3	8	9.2	7.1	30.1	304.8

cont'd

3	9	9.3	7.0	30.2	303.8
3	10	9.3	6.8	30.3	303.3
4	0	8.6	11.1	28.0	316.5
4	1	8.6	11.1	27.8	315.7
4	2	8.9	10.3	28.3	313.8
4	3	9.0	9.2	28.8	311.3
4	4	9.1	8.7	29.2	308.3
4	5	9.1	8.0	29.5	305.2
4	6	9.2	7.7	29.7	304.0
4	7	9.2	6.8	29.9	303.2
4	8	9.2	6.9	29.6	301.5
4	9	9.2	6.6	30.0	300.3
4	10	9.2	6.5	30.2	298.2
5	0	8.0	11.4	27.7	314.3
5	1	8.1	10.9	27.8	315.2
5	2	8.3	9.7	28.6	312.7
5	3	8.4	8.9	28.8	310.5
5	4	8.6	8.5	29.5	309.5
5	5	8.8	8.1	29.5	307.5
5	6	8.8	7.5	29.9	305.3
5	7	8.9	7.3	30.0	305.0
5	8	9.0	7.2	30.2	304.7
5	9	9.1	6.9	30.3	304.3
5	10	9.0	6.6	30.4	314.8
6	0	7.9	11.2	27.6	315.8
6	1	8.0	10.8	28.0	314.8
6	2	8.3	10.0	28.4	313.5
6	3	8.5	9.2	28.7	310.7
6	4	8.6	8.6	29.3	307.3
6	5	8.8	7.8	30.0	306.3
6	6	8.8	7.6	30.0	305.2
6	7	8.9	7.3	30.0	304.8
6	8	8.9	7.0	30.1	302.6
6	9	8.9	6.8	30.3	301.5
6	10	9.0	6.5	30.4	

C.5.2 SEASONAL FIELD AVERAGES OF WINTER FOR PIER A,
DECEMBER, 1984-FEBRUARY, 1985

STATION	DEPTH (m)	DISSOLVED OXYGEN (mg/L)	TEMPERATURE (°C)	SALINITY (°/∞)	CONDUCTIVITY (100 x μ S/cm)
1	0	9.2	3.5	2.79	390.0
2	0	9.6	1.8	28.8	381.0
2	1	9.4	1.1	29.0	380.0
2	2	9.6	0.9	29.2	380.0
2	3	9.7	0.8	29.2	380.0
2	4	9.9	0.9	29.3	380.0
2	5	10.1	0.4	29.3	380.0
2	6	10.3	0.7	29.3	380.0
2	7	10.5	0.6	29.3	380.0
2	8	10.8	0.6	29.3	380.0
2	9	11.1	0.5	29.3	380.0
2	10	11.2	0.5	29.3	380.0
3	0	10.2	1.5	28.6	396.0
3	1	9.0	1.3	29.1	378.0
3	2	9.1	0.9	29.2	350.0
3	3	9.5	0.9	29.3	380.0
3	4	9.8	0.9	29.3	380.0
3	5	10.0	0.9	29.3	380.0
3	6	10.3	0.8	29.3	381.0
3	7	10.6	0.7	29.3	351.0

3	8	10.9	0.7	29.3	351.0
3	9	11.1	0.7	29.3	351.0
3	10	11.2	0.5	29.3	380.0
4	0	9.6	4.2	26.0	370.0
5	0	9.2	1.0	28.5	369.0
5	1	8.9	1.0	29.0	380.0
5	2	8.6	1.0	29.1	380.0
5	3	9.1	0.9	29.1	380.0
5	4	9.2	0.9	29.3	380.0
5	5	9.5	0.9	29.3	380.0
5	6	9.7	0.9	29.3	380.0
5	7	10.1	0.8	29.3	380.0
5	8	10.2	0.7	29.3	380.0
5	9	10.7	0.6	29.3	380.0
5	10	10.7	0.6	29.3	380.0
6	0	10.1	2.0	27.5	380.0
6	1	9.5	1.9	28.6	
6	2	8.5	1.9	28.8	
6	3	9.1	1.9	28.7	
6	4	9.1	1.9	28.8	
6	5	9.1	1.9	29.0	
6	6	9.6	1.9	29.0	
6	7	9.8	1.6	29.0	
6	8	10.3	1.5	29.0	
6	9	10.4	1.5	29.0	
6	10	10.6	1.4	29.0	

C.5.3 SEASONAL FIELD AVERAGES OF SPRING FOR PIER A,
MARCH-MAY, 1985

STATION	DEPTH (m)	DISSOLVED OXYGEN (mg/l.)	TEMPERATURE (°C)	SALINITY (‰)	CONDUCTIVITY (100 x $\mu\Omega$ /cm)
1	0	8.6	5.9	25.0	245.2
2	0	9.2	3.7	30.5	280.3
2	1	9.8	3.3	31.3	282.6
2	2	10.5	3.0	31.4	273.1
2	3	11.0	2.8	31.5	283.7
2	4	11.7	2.5	31.4	280.6
2	5	12.1	2.1	31.8	280.5
2	6	12.1	2.1	31.8	280.1
2	7	12.4	1.9	31.9	279.8
2	8	12.6	1.8	31.9	279.4
2	9	12.5	1.7	31.9	279.2
2	10	12.5	1.5	32.0	279.9
3	0	10.2	3.7	30.9	282.2
3	1	10.2	3.3	31.2	284.8
3	2	10.9	3.0	31.5	285.3
3	3	11.6	2.7	31.6	282.9
3	4	12.0	2.3	31.7	281.2
3	5	12.4	2.1	31.4	279.5
3	6	12.6	2.1	31.6	279.6
3	7	12.8	2.0	31.7	280.1
3	8	12.8	1.9	31.7	278.3
3	9	13.0	1.8	31.7	279.8
3	10	13.1	1.6	31.8	279.2
4	0	8.5	5.7	23.7	238.6
5	0	10.0	3.6	31.1	282.9
5	1	9.9	3.3	31.2	284.5
5	2	10.5	3.0	31.5	283.4
5	3	11.3	2.4	31.5	282.7
5	4	11.7	2.2	31.4	282.7
5	5	12.2	1.8	31.7	281.4
5	6	12.3	1.7	31.8	280.8
5	7	12.5	1.5	31.8	278.9
5	8	12.8	1.4	31.9	277.6
5	9	12.9	1.41	31.9	278.8
5	10	13.0	1.2	31.9	279.0
6	0	10.6	3.0	31.0	282.0
6	1	10.3	2.8	31.2	283.3
6	2	10.8	2.6	31.3	283.3
6	3	11.3	2.4	31.4	282.7
6	4	11.8	2.2	31.4	281.0
6	5	12.2	2.0	31.4	280.0
6	6	12.4	1.7	31.6	280.0
6	7	12.7	1.6	31.6	278.6
6	8	12.6	1.5	31.6	279.9
6	9	13.0	1.4	31.8	278.3
6	10	13.0	1.2	31.9	278.4

C.5.4 SEASONAL FIELD AVERAGES OF SUMMER FOR PIER A,
JUNE-AUGUST, 1985

STATION	DEPTH (m)	DISSOLVED OXYGEN (mg/L)	TEMPERATURE (°C)	SALINITY (‰)	CONDUCTIVITY (100 $\times \mu \Omega / \text{cm}$)
1	0	6.2	12.7	19.5	232.0
2	0	7.9	11.9	26.1	309.2
2	1	8.1	11.3	27.2	316.7
2	2	8.4	10.7	28.3	318.7
2	3	8.6	9.0	28.9	317.0
2	4	8.5	8.2	29.7	312.0
2	5	8.4	7.7	29.8	310.7
2	6	8.3	7.4	29.9	308.3
2	7	8.4	7.1	30.2	306.5
2	8	8.5	6.8	30.4	305.3
2	9	8.5	6.7	30.4	304.0
2	10	8.5	6.5	30.6	312.7
3	0	8.3	11.5	27.1	317.7
3	1	8.4	10.6	28.5	317.0
3	2	8.5	9.8	28.8	314.8
3	3	8.6	9.1	28.7	314.8
3	4	8.7	8.5	29.2	312.5
3	5	8.7	8.3	29.3	312.5
3	6	8.8	7.8	29.6	310.2
3	7	8.9	7.4	29.8	309.3
3	8	8.8	6.7	30.2	295.0
3	9	8.8	6.6	30.3	293.0
3	10	8.7	6.4	30.4	291.5
4	0	7.1	10.2	22.7	253.3
5	0	8.8	11.4	28.0	279.5
5	1	8.9	10.7	28.4	303.3
5	2	9.1	10.2	29.0	303.5
5	3	9.2	9.1	29.0	303.8
5	4	9.2	7.9	29.7	301.0
5	5	9.3	7.4	30.0	297.0
5	6	9.2	7.2	30.2	297.0
5	7	9.2	7.1	30.4	297.0
5	8	9.1	6.7	30.3	294.8
5	9	9.1	6.5	30.6	294.3
5	10	9.0	6.5	30.5	291.5
6	0	8.9	11.1	27.9	318.3
6	1	9.0	10.4	28.6	317.7
6	2	9.2	9.9	28.9	317.7
6	3	9.2	8.7	29.2	309.2
6	4	9.2	7.9	29.6	306.3
6	5	9.1	7.5	29.7	304.3
6	6	9.1	7.1	30.0	304.0
6	7	9.1	7.1	29.9	303.5
6	8	9.1	6.7	30.1	301.2
6	9	9.1	6.2	30.4	298.3
6	10	9.0	6.1	30.4	298.0

APPENDIX D

Halifax Harbour Seasonal Laboratory Data

D.1.1 SEASONAL AVERAGES OF CHEMICAL OXYGEN DEMAND (mg/L)
FOR THE TUFTS COVE SEWER OUTFALL, 1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FALL	WINTER	SPRING	SUMMER
Manhole					217.7	160.1
1	Plume	0			609.3	284.2
2	50	0			375.2	219.5
2A	50	1.0-3.0			450.5	177.0
3	100	0			418.7	179.3
3A	100	2.0-4.0			301.4	140.0
4	150	0			259.4	188.1
4A	150	1.0-4.0			275.4	116.4
5	50	0			210.7	132.6
5A	50	3.0-4.5			245.2	183.0
6	100	0			245.2	162.0
6A	100	2.5-4.0			162.0	183.8
7	150	2.5-4.0			217.7	96.5
7A	150	3.5-5.0			342.4	202.6
8	50	0			295.9	198.1
8A	50	2.5-4.0			257.2	227.7
9	100	0			207.0	235.1
9A	100	5.0-6.0			214.6	184.2
10	150	0			302.9	163.6
10A	150	4.0-7.0			323.7	174.0

D.1.2 SEASONAL AVERAGES OF BIOCHEMICAL OXYGEN DEMAND (mg/L)
FOR THE TUFTS COVE SEWER OUTFALL, 1984-1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FALL	WINTER	SPRING	SUMMER
Manhole				11.0	128.7	86.3
1	Plume	0	56.5	43.8	41.3	62.9
2	50	0	16.5	7.5	6.7	12.9
2A	50	1.0-3.0	6.0	4.6	4.1	5.5
3	100	0	5.4	15.4	3.3	11.8
3A	100	2.0-4.0	3.5	3.2	2.5	3.5
4	150	0	4.7	9.0	4.1	5.5
4A	150	1.0-4.0	2.5	4.7	2.2	2.8
5	50	0	15.0	16.5	11.1	7.4
5A	50	3.0-4.5	7.4	6.1	4.1	3.9
6	100	0	10.2	5.9	8.0	3.9
6A	100	2.5-4.0	3.8	2.9	3.3	3.9
7	150	2.5-4.0	9.6	7.2	3.9	3.8
7A	150	3.5-5.0	3.3	2.0	2.5	2.4
8	50	0	14.7	9.3	8.4	21.7
8A	50	2.5-4.0	5.5	5.1	2.4	3.6
9	100	0	8.2	9.9	3.9	4.9
9A	100	5.0-6.0	4.2	2.8	2.0	2.2
10	150	0	6.7	1.9	2.5	4.6
10A	150	4.0-7.0	3.0	2.4	2.3	2.1

D.1.3 SEASONAL AVERAGES OF SUSPENDED SOLIDS (mg/L)
FOR THE TUFTS COVE SEWER OUTFALL, 1984-1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FALL	WINTER	SPRING	SUMMER
Manhole				120.8	122.3	55.9
1	Plume	0	110.0	60.1	71.8	61.4
2	50	0	79.6	33.3	30.0	17.5
2A	50	1.0-3.0	12.7	32.9	39.6	9.2
3	100	0	12.8	63.0	26.1	14.7
3A	100	2.0-4.0	17.5	79.7	25.8	8.6
4	150	0	18.1	55.0	28.6	17.5
4A	150	1.0-4.0	16.4	34.4	25.6	9.7
5	50	0	27.2	32.3	28.2	12.9
5A	50	3.0-4.5	12.6	13.9	42.9	11.8
6	100	0	19.3	21.4	46.3	13.6
6A	100	2.5-4.0	15.5	22.3	34.0	14.4
7	150	2.5-4.0	17.8	31.0	31.5	13.0
7A	150	3.5-5.0	15.3	35.2	30.1	13.2
8	50	0	23.5	61.6	34.3	29.5
8A	50	2.5-4.0	19.9	33.1	29.1	12.7
9	100	0	26.9	38.6	29.3	27.7
9A	100	5.0-6.0	15.9	29.9	30.8	10.4
10	150	0	22.2	31.1	30.0	12.2
10A	150	4.0-7.0	25.9	26.4	27.2	14.2

D.1.4 SEASONAL AVERAGES OF pH USING [H+] FOR
THE TUFTS COVE SEWER OUTFALL, 1984-1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FALL	WINTER	SPRING	SUMMER
Manhole				6.74	7.59	6.96
1	Plume	0	7.80	7.37	8.11	7.66
2	50	0	7.91	7.51	7.77	7.92
2A	50	1.0-3.0	7.86	7.53	7.97	7.99
3	100	0	7.93	7.37	7.96	8.05
3A	100	2.0-4.0	7.91	7.57	7.99	8.03
4	150	0	7.68	7.22	7.92	7.91
4A	150	1.0-4.0	7.88	7.60	8.00	8.00
5	50	0	7.71	7.41	8.01	8.10
5A	50	3.0-4.5	7.99	7.70	7.99	8.06
6	100	0	7.94	7.68	8.01	8.12
6A	100	2.5-4.0	7.96	7.74	8.01	8.08
7	150	2.5-4.0	8.00	7.71	8.00	8.15
7A	150	3.5-5.0	8.01	7.77	8.03	8.07
8	50	0	8.01	7.93	8.06	7.93
8A	50	2.5-4.0	7.94	7.80	8.02	8.05
9	100	0	7.99	7.77	8.06	8.04
9A	100	5.0-6.0	7.97	7.83	8.04	8.05
10	150	0	8.03	7.82	8.04	8.10
10A	150	4.0-7.0	8.02	7.83	8.04	8.03

D.2.1 SEASONAL AVERAGES OF CHEMICAL OXYGEN DEMAND (mg/L) FOR
THE DUFFUS STREET SEWER OUTFALL, 1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FALL	WINTER	SPRING	SUMMER
Manhole					133.6	187.3
1	Plume	0			149.9	157.3
2	50	0			104.1	92.8
2A	50	9-13			108.6	120.0
3	100	0			108.3	117.8
3A	100	20-23			104.4	90.9
4	150	0			104.4	87.8
4A	150	20-24			180.4	91.2
5	50	0			77.9	110.6
5A	50	6-8			131.6	77.1
6	100	0			137.6	100.4
6A	100	10-13			99.3	151.9
7	150	0			113.6	140.0
7A	150	12-15			142.7	138.3
8	50	0			56.7	200.1
8A	50	13-16			107.5	195.3
9	100	0			99.2	136.4
9A	100	15-18			156.2	144.0
10	150	0			128.5	155.8
10A	150	20-23			81.3	171.1

D.2.2 SEASONAL AVERAGES OF BIOCHEMICAL OXYGEN DEMAND (mg/L) FOR
THE DUFFUS STREET SEWER OUTFALL, 1984-1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FALL	WINTER	SPRING	SUMMER
Manhole					43.1	83.8
1	Plume	0	29.0	32.8	26.2	33.9
2	50	0	15.5	14.8	4.7	6.7
2A	50	9-13	4.7	5.0	2.0	2.1
3	100	0	6.2	5.1	3.0	3.1
3A	100	20-23	3.0	3.9	1.7	1.5
4	150	0	4.8	2.5	3.4	2.2
4A	150	20-24	4.1	3.2	1.6	1.4
5	50	0	13.1	6.6	3.8	6.6
5A	50	6-8	9.1	5.7	2.1	1.8
6	100	0	7.7	5.6	2.1	3.2
6A	100	10-13	2.8	2.9	1.7	1.4
7	150	0	5.4	5.8	2.1	3.3
7A	150	12-15	2.6	3.1	1.7	1.5
8	50	0	21.5	6.7	4.6	5.4
8A	50	13-16	7.8	2.2	1.7	2.2
9	100	0	5.2	2.4	2.7	4.5
9A	100	15-18	2.7	1.7	1.5	1.3
10	150	0	5.5	3.9	2.3	2.8
10A	150	20-23	2.6	1.3	1.6	1.3

D.2.3 SEASONAL AVERAGES OF SUSPENDED SOLIDS (mg/L) FOR
THE DUFFUS STREET SEWER OUTFALL, 1984-1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FALL	WINTER	SPRING	SUMMER
Manhole						
1	Plume	0	31.6	38.0	47.6	56.5
2	50	0	20.6	23.2	30.8	12.8
2A	50	9-13	13.7	27.8	29.0	7.1
3	100	0	13.1	25.1	30.1	10.8
3A	100	20-23	18.7	18.0	26.8	11.7
4	150	0	30.8	17.3	30.1	8.1
4A	150	20-24	28.1	18.8	27.3	7.2
5	50	0	23.6	23.6	25.6	9.9
5A	50	6-8	26.8	22.9	38.5	9.4
6	100	0	24.6	16.5	27.4	8.5
6A	100	10-13	14.1	16.7	19.3	9.6
7	150	0	24.5	14.9	29.0	12.8
7A	150	12-15	31.0	26.8	27.3	11.6
8	50	0	23.9	23.5	27.8	17.5
8A	50	13-16	23.7	16.5	31.8	10.1
9	100	0	25.9	30.5	26.6	10.9
9A	100	15-18	28.0	24.0	26.9	7.0
10	150	0	26.1	21.5	28.4	9.2
10A	150	20-23	19.1	31.5	25.6	10.0

D.2.4 SEASONAL AVERAGES OF pH USING [H+] FOR
THE DUFFUS STREET SEWER OUTFALL, 1984-1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FALL	WINTER	SPRING	SUMMER
Manhole						
1	Plume	0	7.19	7.43	7.20	6.53
2	50	0	7.66	7.53	7.45	7.12
2A	50	9-13	7.37	7.75	7.98	7.77
3	100	0	7.94	7.85	8.05	7.98
3A	100	20-23	7.96	7.89	8.02	8.05
4	150	0	7.96	7.89	8.04	7.99
4A	150	20-24	7.88	7.92	8.04	8.11
5	50	0	7.91	7.95	8.06	7.99
5A	50	6-8	7.95	7.91	8.00	7.94
6	100	0	7.97	7.89	8.03	8.00
6A	100	10-13	7.90	7.88	8.01	8.05
7	150	0	7.99	7.91	8.03	8.00
7A	150	12-15	7.92	7.91	8.02	8.06
8	50	0	7.93	7.90	8.04	8.00
8A	50	13-16	7.97	7.95	8.01	7.98
9	100	0	8.01	7.91	8.04	7.98
9A	100	15-18	7.99	7.89	8.01	8.04
10	150	0	8.00	7.87	8.03	7.98
10A	150	20-23	7.95	7.91	8.02	8.11
			7.93	7.92	8.05	7.98

D.3.1 SEASONAL AVERAGES OF CHEMICAL OXYGEN DEMAND (mg/L) FOR
THE DARTMOUTH COVE SEWER OUTFALL, 1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FALL	WINTER	SPRING	SUMMER
Manhole						
1	Plume 1	0			314.9	202.3
2	75	0			188.1	132.6
2A	75	5.0-7.0			139.9	131.5
3	125	0			111.3	98.5
3A	125	4.5-7.0			112.6	106.5
4	Plume 2	0			79.7	70.2
5	50	0			103.7	124.7
5A	50	5.5-6.0			154.6	120.6
6	50	0			112.6	101.0
6A	50	4.0-5.0			113.9	128.1
7	50	0			121.7	112.0
7A	50	4.5-6.0			143.0	108.8
8	100	0			62.3	96.8
8A	100	3.5-7.0			99.8	102.9
9	150	0			84.2	133.0
9A	150	7.0-7.0			69.2	122.0
10	200	0			76.2	117.0
10A	200	10			89.1	120.4
					65.0	115.1

D.3.2 SEASONAL AVERAGES OF BIOCHEMICAL OXYGEN DEMAND (mg/L) FOR
THE DARTMOUTH COVE SEWER OUTFALL, 1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FALL	WINTER	SPRING	SUMMER
Manhole						
1	Plume 1	0		121.5	83.4	60.3
2	75	0	22.4	28.8	23.3	26.2
2A	75	5.0-7.0	11.8	7.7	6.3	7.9
3	125	0	8.0	3.4	2.3	3.3
3A	125	4.5-7.0	6.4	4.7	3.8	4.8
4	Plume 2	0	3.4	3.4	2.0	2.7
5	50	0	12.9	22.9	15.3	15.5
5A	50	5.5-6.0	6.8	3.4	3.6	4.3
6	50	0	3.6	2.1	2.0	2.6
6A	50	4.0-5.0	9.9	2.3	7.1	7.9
7	50	0	4.3	3.3	4.3	3.6
7A	50	4.5-6.0	10.7	7.2	4.6	7.4
8	100	0	4.8	3.7	2.7	3.4
8A	100	3.5-7.0	9.1	4.8	3.7	5.6
9	150	0	3.4	2.8	1.9	2.9
9A	150	7.0-7.0	5.8	2.6	3.2	4.3
10	200	0	2.3	2.0	1.9	2.5
10A	200	10		2.5	2.8	3.9
				2.5	1.8	2.5

D.3.3 SEASONAL AVERAGES OF SUSPENDED SOLIDS (mg/L) FOR
THE DARTMOUTH COVE SEWER OUTFALL, 1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FALL	WINTER	SPRING	SUMMER
Manhole						
1	Plume 1	0	24.2	95.3	83.9	94.7
2	75	0	15.4	44.0	56.2	32.3
2A	75	5.0-7.0	13.8	36.9	37.5	11.2
3	125	0	17.3	41.9	30.1	9.3
3A	125	4.5-7.0	19.3	43.9	32.4	15.0
4	Plume 2	0	14.7	39.8	38.6	17.5
5	50	0	21.3	33.5	30.0	11.8
5A	50	5.5-6.0	27.4	47.5	33.7	9.7
6	50	0	18.7	41.4	37.5	17.2
6A	50	4.0-5.0	18.8	35.9	37.4	10.3
7	50	0	18.8	29.1	30.8	11.8
7A	50	4.5-6.0	24.9	36.3	36.1	9.3
8	100	0	11.3	35.1	28.1	11.6
8A	100	3.5-7.0	14.7	36.6	31.0	11.5
9	150	0	18.3	36.8	29.7	7.8
9A	150	7.0-7.0	24.9	39.2	31.6	6.8
10	200	0		31.7	29.4	8.9
10A	200	0		35.3	39.8	8.4

D.3.4 SEASONAL AVERAGES OF pH USING [H+] FOR
THE DARTMOUTH COVE SEWER OUTFALL, 1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FALL	WINTER	SPRING	SUMMER
Manhole						
1	Plume 1	0	7.94	7.71	7.74	7.10
2	75	0	7.95	7.71	7.79	7.67
2A	75	5.0-7.0	8.00	7.87	7.74	7.91
3	125	0	7.98	7.87	8.00	7.95
3A	125	4.5-7.0	8.01	7.82	7.96	8.02
4	Plume 2	0	7.46	7.78	8.00	7.96
5	50	0	7.46	7.78	7.89	7.89
5A	50	5.5-6.0	7.98	7.81	8.00	8.03
6	50	0	7.85	7.85	8.03	8.07
6A	50	4.0-5.0	7.99	7.66	7.93	8.01
7	50	0	7.98	7.87	7.87	7.96
7A	50	4.5-6.0	7.98	7.86	7.97	7.92
8	100	0	7.95	7.85	7.97	7.93
8A	100	3.5-7.0	7.98	7.87	7.99	8.04
9	150	0	8.02	7.87	8.00	8.00
9A	150	7.0-7.0	7.74	7.90	7.99	8.10
10	200	0	7.74	7.90	8.03	8.04
10A	200	10		7.95	8.02	8.09
				7.97	8.02	8.10

DATA FOR MONITORING OF BIOLOGICAL OXYGEN DEMAND (BOD) FOR
THE SACKVILLE STREET SEWER OUTFALL, 1985

- 430 -

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FALL	WINTER	SPRING	SUMMER
Manhole					523.6	281.5
1	Plume	0			173.4	137.3
2	50	0			115.9	145.2
2A	50	10			201.4	106.6
3	100	0			188.8	136.5
3A	100	16			143.1	134.8
4	150	0			177.8	132.1
4A	150	19.5			142.8	137.9
5	50	0			90.1	116.4
5A	50	11			143.7	137.2
6	50	0			245.5	119.4
6A	50	10			202.8	111.2

D.4.2 SEASONAL AVERAGES OF BIOCHEMICAL OXYGEN DEMAND (mg/L) FOR
THE SACKVILLE STREET SEWER OUTFALL, 1984-1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FALL	WINTER	SPRING	SUMMER
Manhole				175.0	170.8	116.0
1	Plume	0		20.5	30.3	19.9
2	50	0		11.4	6.0	8.0
2A	50	10		4.5	2.4	2.9
3	100	0		10.1	2.5	3.6
3A	100	16		3.8	1.7	2.4
4	150	0		5.4	2.1	3.5
4A	150	19.5		2.8	1.6	2.3
5	50	0		5.2	3.5	4.2
5A	50	11		2.6	1.7	2.2
6	50	0		3.2	2.2	3.9
6A	50	10		1.8	1.8	2.3

D.4.3 SEASONAL AVERAGES OF SUSPENDED SOLIDS (mg/L) FOR
THE SACKVILLE STREET SEWER OUTFALL, 1984-1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FALL	WINTER	SPRING	SUMMER
Manhole				101.0	94.8	1212.1
1	Plume	0		61.2	53.6	19.6
2	50	0		10.1	29.7	12.2
2A	50	10		11.3	32.5	7.8
3	100	0		39.3	35.3	8.1
3A	100	16		39.6	28.7	8.9
4	150	0		35.8	31.5	11.4
4A	150	19.5		40.7	27.9	8.1
5	50	0		28.8	26.7	11.4
5A	50	11		41.9	30.9	15.3
6	50	0		23.3	28.7	9.4
6A	50	10		24.6	26.2	7.2

D.4.4 SEASONAL AVERAGES OF pH USING [H+] FOR THE
SACKVILLE STREET SEWER OUTFALL, 1984-1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FALL	WINTER	SPRING	SUMMER
Manhole					7.90	8.05
1	Plume	0		7.98	8.10	7.99
2	50	0		8.00	8.00	8.09
2A	50	10		8.00	8.00	8.11
3	100	0		8.01	8.00	8.16
3A	100	16		8.03	8.10	8.15
4	150	0		8.05	8.04	8.21
4A	150	19.5		8.07	8.00	8.12
5	50	0		8.04	8.00	8.16
5A	50	11		8.09	8.00	8.13
6	50	0		8.02	8.00	8.18
6A	50	10		8.07	8.00	8.14

D.5.1 SEASONAL AVERAGES OF CHEMICAL OXYGEN DEMAND (mg/L) FOR THE PIER "A" OUTFALL, 1985

- 431 -

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FALL	WINTER	SPRING	SUMMER
Manhole					682.6	261.9
1	Plume 1	0			190.3	141.3
2	200	0			119.3	83.6
2A	200	12			137.6	90.2
3	400	0			126.4	74.4
3A	400	17			184.2	91.3
4	Plume 2	0			160.2	166.6
5	50	0			116.1	100.8
5A	50	19			105.0	107.4
6	100	0			155.3	143.3
6A	100	9			206.2	95.0

D.5.2 SEASONAL AVERAGES OF BIOCHEMICAL OXYGEN DEMAND (mg/L) FOR THE PIER "A" OUTFALL, 1984-1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FALL	WINTER	SPRING	SUMMER
Manhole				135.0	123.3	91.3
1	Plume 1	0		27.5	27.6	40.9
2	200	0		6.3	4.9	6.3
2A	200	12		2.6	2.1	2.7
3	400	0		6.0	3.6	4.1
3A	400	17		3.5	2.0	2.1
4	Plume 2	0		38.5	33.0	29.4
5	50	0		2.0	2.0	2.2
5A	50	19		4.1	3.5	4.5
6	100	0		2.3	1.7	2.2
6A	100	9		2.7	3.4	4.0

D.5.3 SEASONAL AVERAGES OF SUSPENDED SOLIDS (mg/L) FOR THE PIER "A" OUTFALL, 1984-1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FALL	WINTER	SPRING	SUMMER
Manhole				72.9	72.0	46.9
1	Plume 1	0		34.4	52.1	62.4
2	200	0		35.0	27.9	14.0
2A	200	12		28.3	28.1	9.6
3	400	0		25.9	31.2	13.2
3A	400	17		34.6	25.8	12.8
4	Plume 2	0		37.2	47.9	51.1
5	50	0		30.7	29.3	13.0
5A	50	19		35.3	27.2	8.2
6	100	0		28.6	27.3	10.8
6A	100	9		31.2	29.9	9.0

D.5.4 SEASONAL AVERAGES OF pH USING [H+] FOR THE PIER "A" OUTFALL, 1984-1985

STATION	DISTANCE FROM THE PLUME (m)	DEPTH (m)	FALL	WINTER	SPRING	SUMMER
Manhole					7.51	7.18
1	Plume 1	0		7.97	7.70	7.73
2	200	0		8.05	8.03	8.13
2A	200	12		8.09	8.02	8.02
3	400	0		8.06	8.05	8.18
3A	400	17		8.08	8.03	8.06
4	Plume 2	0		7.94	7.68	7.88
5	50	0		8.04	8.05	8.21
5A	50	19		8.10	8.03	8.15
6	100	0		7.97	8.03	8.20
6A	100	9		8.03	8.02	8.16

APPENDIX R

Halifax Harbour Seasonal Reference Data

R.1 SEASONAL REFERENCE DATA FOR AUTUMN, 1984.

STATION	DEPTH (m)	DISSOLVED OXYGEN (mg/L)	TEMPERATURE (°C)	SALINITY (o/∞)	CONDUCTIVITY (100 x $\mu\Omega$ /cm)
1	0	8.9	9.0		
1	1	9.1			
1	2	9.5			
1	3	9.0			
1	4	9.3			
1	5	11.0			
1	6	11.0			
1	7	10.0			
1	8	11.2			
1	9	10.2			
2	0	9.0	9.0		
2	1	8.4			
2	2	8.6			
2	3	8.8			
2	4	9.2			
2	5	10.2			
2	6	10.9			
2	7	10.4			
2	8	10.4			
2	9	10.4			
3	0	9.5	9.0		
3	1	8.2			
3	2	8.9			
3	3	9.5			
3	4	9.9			
3	5	10.5			
3	6	11.0			
3	7	11.1			
3	8	11.2			
3	9	11.2			
3	10	11.2			
4	0	11.6	9.2		
4	1	11.5			
4	2	11.3			
4	3	11.3			
4	4	11.2			
4	5	11.2			
4	6	11.2			
4	7	11.2			
4	8	11.2			
4	9	11.3			
4	10	11.4			

R.1, Cont.

5	0	11.2	9.0
5	1	10.7	
5	2	11.0	
5	3	11.2	
5	4	11.4	
5	5	11.2	
5	6	11.2	
5	7	11.2	
5	8	11.7	
5	9	11.8	
5	10	11.9	
6	0	11.0	9.0
6	1	10.7	
6	2	11.0	
6	3	10.7	
6	4	10.6	
6	5	10.6	
6	6	10.7	
6	7	11.0	
6	8	11.0	
6	9	11.1	
6	10	11.0	
7	0	10.5	9.0
7	1	10.5	
7	2	10.5	
7	3	10.8	
7	4	10.7	
7	5	10.7	
7	6	11.0	
7	7	11.1	
7	8	11.2	
7	9	11.4	
7	10	11.3	
8	0	10.5	9.2
8	1	10.2	
8	2	10.4	
8	3	10.7	
8	4	11.0	
8	5	11.4	
8	6	11.8	
8	7	11.7	
8	8	12.2	
8	9	13.0	
8	10	12.6	

R.I., Cont.

9	0	11.0	9.0
9	1	10.5	
9	2	11.4	
9	3	11.3	
9	4	11.3	
9	5	11.2	
9	6	11.4	
9	7	11.7	
9	8	11.8	
9	9	11.9	
9	10	12.2	
10	0	9.3	9.0
10	1	9.5	
10	2	9.9	
10	3	10.5	
10	4	10.7	
10	5	10.8	
10	6	11.0	
10	7	11.1	
10	8	11.2	
10	9	11.4	
10	10	11.4	
11	0	9.4	8.0
11	1	10.1	
11	2	10.7	
11	3	11.4	
11	4	12.5	
11	5	13.0	
11	6	11.1	
11	7	11.0	
11	8	13.0	
11	9	12.2	
11	10	12.9	
12	0	8.5	8.5
12	1	10.0	
12	2	10.5	
12	3	10.6	
12	4	10.6	
12	5	10.2	
12	6	10.0	
12	7	9.9	
12	8	9.8	
12	9	10.0	
12	10	9.8	
13	0	8.6	9.5
13	1	8.7	
13	2	8.9	
13	3	9.1	
13	4	9.7	
13	5	9.9	
13	6	10.2	
13	7	11.4	
13	8	11.7	
13	9	11.9	

R.1, Cont.

14	0	8.6	9.0
14	1	9.2	
14	2	9.1	
14	3	8.8	
14	4	9.4	
14	5	9.5	
14	6	9.8	
14	7	10.0	
14	8	10.1	
14	9	10.5	
14	10	10.6	
15	0	8.8	9.0
15	1	8.6	
15	2	8.6	
15	3	8.7	
15	4	8.9	
15	5	9.3	
15	6	9.8	
15	7	9.9	
15	8	10.1	
15	9	10.1	
16	0	8.8	9.0
16	1	8.9	
16	2	8.8	
16	3	9.1	
16	4	9.3	
16	5	9.4	
16	6	9.5	
16	7	10.0	
16	8	10.1	
16	9	10.4	
17	0	8.6	9.0
17	1	8.5	
17	2	8.5	
17	3	8.3	
17	4	8.2	
17	5	8.3	
17	6	8.8	
17	7	9.1	
17	8	9.3	
17	9	9.2	
17	10	9.8	
18	0	9.1	9.0
18	1	8.8	
18	2	8.7	
18	3	8.8	
18	4	9.1	
18	5	9.5	
18	6	9.5	
18	7	10.0	
18	8	10.1	
18	9	10.1	
18	10	10.4	

R.2 SEASONAL REFERENCE DATA FOR WINTER, 1984-1985.

STATION	DEPTH (m)	DISSOLVED OXYGEN (mg/L)	TEMPERATURE (°C)	SALINITY (o/oo)	CONDUCTIVITY (100 x $\mu\Omega$ /cm)
1	0	9.6	2.0	10.0	
1	1	9.4	2.0	22.9	
1	2	10.0	2.0	26.0	
1	3	11.0	1.3	28.0	
1	4	12.0	1.2	28.2	
1	5	12.7	1.0	28.2	
1	6	13.2	1.0	28.2	
1	7	13.8	1.0	28.4	
1	8	14.4	1.0	29.0	
1	9	14.6	1.0	29.0	
1	10	14.6	0.9	28.9	
2	0	9.8	2.0	10.5	
2	1	9.4	2.0	26.0	
2	2	9.9	1.9	28.5	
2	3	11.0	1.2	29.0	
2	4	11.8	1.0	29.0	
2	5	12.2	1.0	29.0	
2	6	13.0	1.0	29.0	
2	7	13.8	1.0	29.0	
2	8	14.2	1.0	29.0	
2	9	14.7	1.0	29.1	
2	10	15.0	0.9	29.0	
3	0	11.0	2.3	13.0	
3	1	10.0	2.0	25.0	
3	2	10.2	1.9	28.0	
3	3	10.8	1.9	29.0	
3	4	11.8	1.2	29.0	
3	5	12.4	1.0	29.0	
3	6	13.2	1.0	29.0	
3	7	13.7	1.0	29.0	
3	8	14.2	1.0	29.0	
3	9	14.5	1.0	29.0	
3	10	14.8	1.0	29.0	
4	0	10.4	2.0	10.0	
4	1	9.8	2.0	25.5	
4	2	9.8	2.0	28.8	
4	3	10.4	1.2	29.0	
4	4	11.0	1.0	29.0	
4	5	12.0	1.0	29.0	
4	6	12.6	1.0	29.0	
4	7	13.2	1.0	29.0	
4	8	13.6	1.0	29.0	
4	9	14.0	1.0	29.0	
4	10	14.4	1.0	29.0	

R.2, Cont.

5	0	10.8	2.1	13.0
5	1	9.8	2.0	27.0
5	2	10.0	1.4	29.0
5	3	10.5	1.0	29.0
5	4	11.2	1.0	29.0
5	5	12.0	1.0	29.0
5	6	12.8	1.0	29.0
5	7	13.2	1.0	29.0
5	8	13.8	1.0	29.0
5	9	14.2	0.9	29.0
5	10	14.4	0.9	29.0
6	0	11.4	2.0	17.0
6	1	10.0	1.8	29.2
6	2	9.9	1.1	30.1
6	3	10.4	1.0	30.6
6	4	11.2	0.9	30.9
6	5	12.0	0.7	30.9
6	6	12.6	0.8	30.9
6	7	13.0	0.6	30.9
6	8	13.4	0.6	30.9
6	9	13.8	0.5	30.9
6	10	14.2	0.5	31.0
7	0	9.8	1.9	25.0
7	1	9.0	1.2	29.0
7	2	9.2	1.0	30.1
7	3	9.8	0.9	30.2
7	4	10.8	0.9	30.5
7	5	11.4	0.8	30.5
7	6	12.0	0.6	30.6
7	7	12.6	0.5	30.5
7	8	13.0	0.5	30.5
7	9	13.4	0.4	30.6
7	10	14.0	0.4	30.6
8	0	10.8	1.0	29.0
8	1	9.8	1.0	30.0
8	2	9.5	1.0	30.1
8	3	9.8	0.9	30.2
8	4	10.4	0.8	30.3
8	5	11.2	0.8	30.0
8	6	11.8	0.7	30.0
8	7	12.4	0.7	30.0
8	8	12.8	0.7	30.0
8	9	13.2	0.5	30.0
8	10	13.8	0.4	30.0

R.2, Cont.

9	0	11.2	1.2	28.8
9	1	9.8	1.0	29.7
9	2	9.6	1.0	29.8
9	3	9.8	1.0	30.0
9	4	10.0	0.9	30.2
9	5	11.0	0.9	30.2
9	6	11.6	0.8	30.3
9	7	12.4	0.6	30.3
9	8	13.0	0.6	30.3
9	9	13.2	0.5	30.2
9	10	13.6	0.5	30.2
10	0	12.6	1.1	29.0
10	1	10.6	1.1	29.1
10	2	11.0	1.0	30.0
10	3	11.8	1.0	30.0
10	4	12.8	1.0	30.1
10	5	13.6	1.0	30.1
10	6	14.0	0.9	30.2
10	7	14.6	0.9	30.2
10	8	15.2	0.9	30.2
10	9	15.8	0.8	30.2
10	10	16.0	0.7	30.2
11	0	11.2	1.2	30.0
11	1	9.4	1.2	30.0
11	2	9.6	1.1	30.0
11	3	10.8	1.0	30.2
11	4	11.0	1.0	30.2
11	5	12.8	1.0	30.2
11	6	13.6	1.0	30.2
11	7	14.2	1.0	30.4
11	8	14.8	0.9	30.3
11	9	15.2	0.9	30.2
11	10	15.4	0.8	30.3
12	0	11.6	1.6	29.8
12	1	9.8	1.4	29.8
12	2	9.6	1.4	30.0
12	3	10.6	1.1	30.0
12	4	11.4	1.0	30.1
12	5	12.6	1.0	30.2
12	6	13.0	1.0	30.2
12	7	13.8	1.0	30.2
12	8	14.4	0.9	30.2
12	9	14.8	0.9	30.2
12	10	15.2	0.8	30.2
13	0	12.4	1.8	29.8
13	1	10.0	1.6	29.8
13	2	9.8	1.2	30.0
13	3	10.4	1.1	30.0
13	4	11.6	1.2	30.2
13	5	12.2	1.0	30.2
13	6	13.0	1.0	30.1
13	7	13.6	1.0	30.2
13	8	14.4	1.0	30.1
13	9	14.8	1.0	30.1
13	10	15.0	1.0	30.1

R.2, Cont.

14	0	12.2	1.9	29.1
14	1	9.8	1.6	29.8
14	2	9.6	1.5	30.0
14	3	10.0	1.2	30.0
14	4	11.0	1.1	30.1
14	5	12.0	1.0	30.1
14	6	12.6	1.0	30.0
14	7	13.2	1.0	30.0
14	8	13.8	1.0	30.1
14	9	14.4	1.0	30.1
14	10	14.8	1.0	30.1
15	0	12.6	2.0	28.8
15	1	10.4	1.8	30.0
15	2	9.4	1.5	30.0
15	3	9.9	1.2	30.0
15	4	11.0	1.0	30.0
15	5	11.8	1.0	30.0
15	6	12.2	1.0	30.0
15	7	13.0	1.0	30.0
15	8	13.6	1.0	30.0
15	9	14.0	1.0	30.0
15	10	14.6	1.0	30.1
16	0	12.4	2.0	28.0
16	1	10.0	2.0	28.0
16	2	9.4	1.5	30.0
16	3	9.8	1.3	30.0
16	4	10.6	1.1	30.0
16	5	11.4	1.0	30.0
16	6	12.2	1.0	30.0
16	7	12.8	1.0	30.0
16	8	13.4	1.0	30.0
16	9	14.2	1.0	30.0
16	10	14.6	0.9	30.1
17	0	13.8	2.0	27.0
17	1	10.2	2.0	28.0
17	2	9.4	1.8	30.0
17	3	10.2	1.5	30.1
17	4	11.0	1.0	30.1
17	5	11.6	1.0	30.0
17	6	12.0	1.0	30.0
17	7	13.0	1.0	30.0
17	8	13.6	1.0	30.0
17	9	13.8	1.0	30.0
17	10	14.6	1.0	30.0
18	0	11.8	2.0	26.0
18	1	9.8	1.7	30.0
18	2	9.0	1.5	30.0
18	3	9.9	1.1	30.0
18	4	10.4	1.0	30.0
18	5	11.6	1.0	30.0
18	6	12.2	1.0	30.0
18	7	12.8	1.0	30.0
18	8	13.2	0.9	30.0
18	9	13.4	1.0	30.0
18	10	13.4	1.0	30.0

R.3 SEASONAL REFERENCE DATA FOR SPRING, 1985.

STATION	DEPTH (m)	DISSOLVED OXYGEN (mg/L)	TEMPERATURE (°C)	SALINITY (o/oo)	CONDUCTIVITY (100 x $\mu\Omega$ /cm)
1	0	9.4	3.8	32.5	295.0
1	1	9.5	3.7	32.5	295.0
1	2	9.8	3.5	32.4	295.0
1	3	10.0	3.5	32.4	295.0
1	4	9.8	3.1	32.8	294.0
1	5	10.0	3.0	32.8	294.0
1	6	10.0	3.0	32.5	291.0
1	7	9.6	3.0	32.4	291.0
1	8	9.7	2.7	33.0	290.0
1	9	9.4	2.0	32.5	288.0
1	10	9.9	2.0	32.5	285.0
2	0	9.0	3.8	32.4	295.0
2	1	9.0	3.8	32.3	295.0
2	2	9.2	3.8	32.5	295.0
2	3	9.3	3.8	32.5	295.0
2	4	9.4	3.7	32.8	295.0
2	5	9.6	3.7	32.1	293.0
2	6	9.6	3.5	32.0	290.0
2	7	9.7	3.0	32.0	290.0
2	8	10.2	2.5	31.0	285.0
2	9	10.3	2.0	33.0	285.0
2	10	10.4	2.0	32.8	282.0
3	0	9.4	4.0	32.0	295.0
3	1	9.8	3.9	33.0	296.0
3	2	10.0	3.9	32.5	295.0
3	3	9.7	3.8	32.4	294.0
3	4	9.6	3.7	32.3	292.0
3	5	9.7	3.3	32.2	292.0
3	6	9.6	3.1	32.0	291.0
3	7	10.2	2.0	33.0	286.0
3	8	10.0	2.0	33.0	285.0
3	9	10.3	1.5	33.0	281.0
3	10	10.3	1.5	32.9	280.0
4	0	9.6	4.0	33.0	296.0
4	1	9.7	3.9	33.0	295.0
4	2	9.9	3.8	33.2	292.0
4	3	10.0	3.6	32.5	295.0
4	4	10.0	3.7	32.2	295.0
4	5	10.2	3.7	32.2	295.0
4	6	10.3	3.6	32.1	292.0
4	7	10.3	3.6	32.1	292.0
4	8	10.4	3.6	32.1	293.0
4	9	10.5	3.6	32.1	292.0
4	10	10.5	3.2	32.7	291.0

R.3, Cont.

5	0	9.9	3.8	32.0	292.0
5	1	10.1	3.7	32.0	294.0
5	2	10.1	3.6	32.0	293.0
5	3	10.3	3.5	32.1	292.0
5	4	10.4	3.5	32.0	291.0
5	5	10.4	3.5	32.6	292.0
5	6	10.5	3.1	32.3	290.0
5	7	10.5	3.1	32.6	292.0
5	8	10.5	3.0	32.2	290.0
5	9	10.5	3.0	31.9	290.0
5	10	10.6	2.0	33.2	288.0
6	0	9.7	3.7	34.0	292.0
6	1	10.0	3.5	32.1	290.0
6	2	10.0	3.2	32.1	290.0
6	3	10.0	3.2	32.3	290.0
6	4	10.1	3.0	32.4	290.0
6	5	10.2	3.0	32.2	290.0
6	6	10.4	2.9	32.1	289.0
6	7	10.4	2.8	32.1	289.0
6	8	10.4	2.8	32.1	289.0
6	9	10.4	2.0	32.9	284.0
6	10	10.5	3.0	32.5	290.0
7	0	9.6	3.0	32.6	290.0
7	1	9.7	2.9	32.2	290.0
7	2	9.9	2.6	32.9	289.0
7	3	10.0	2.5	32.9	289.0
7	4	10.0	2.5	32.8	289.0
7	5	10.3	2.5	32.7	290.0
7	6	10.3	2.5	32.8	290.0
7	7	10.4	2.5	32.9	289.0
7	8	10.5	2.2	33.0	289.0
7	9	10.5	2.2	33.1	288.0
7	10	10.6	3.0	32.0	289.0
8	0	9.7	3.0	32.0	289.0
8	1	9.8	3.0	32.0	289.0
8	2	10.0	3.0	32.0	289.0
8	3	10.1	3.0	32.0	288.0
8	4	10.1	3.0	32.0	289.0
8	5	10.2	2.5	31.9	286.0
8	6	10.3	2.5	31.9	286.0
8	7	10.3	2.2	32.6	285.0
8	8	10.6	2.2	32.6	285.0
8	9	10.6	2.1	32.8	287.0
8	10	10.6			

R.3, Cont.

9	0	9.3	3.5	32.0	290.0
9	1	9.6	3.2	32.2	290.0
9	2	9.8	3.0	32.5	290.0
9	3	9.9	3.0	32.5	290.0
9	4	10.0	3.0	32.4	290.0
9	5	10.2	3.0	32.3	290.0
9	6	10.4	3.0	32.3	290.0
9	7	10.4	2.8	32.2	289.0
9	8	10.5	2.5	32.6	289.0
9	9	10.5	2.5	32.6	289.0
9	10	10.5	2.5	32.6	289.0
10	0	9.7	.2	32.5	291.0
10	1	9.9	3.1	33.0	295.0
10	2	10.0	3.1	33.0	294.0
10	3	10.0	3.1	32.7	291.0
10	4	10.2	3.1	32.6	290.0
10	5	10.4	3.0	32.6	290.0
10	6	10.4	3.0	32.3	290.0
10	7	10.5	2.7	32.5	290.0
10	8	10.5	2.7	33.1	290.0
10	9	10.5	2.7	32.9	290.0
10	10	10.6	2.3	33.2	291.0
11	0	9.6	3.3	35.0	312.0
11	1	9.4	3.3	35.0	313.0
11	2	9.4	3.3	35.0	313.0
11	3	9.6	3.3	35.0	313.0
11	4	9.8	3.3	35.0	313.0
11	5	10.0	3.1	35.0	312.0
11	6	10.0	3.1	35.0	312.0
11	7	10.2	3.1	35.0	312.0
11	8	10.3	3.0	35.0	312.0
11	9	10.4	3.0	34.9	311.0
11	10	10.4	3.0	34.9	310.0
12	0	9.6	3.4	35.0	312.0
12	1	9.4	3.3	35.0	312.0
12	2	9.5	3.3	35.0	313.0
12	3	9.8	3.3	35.0	313.0
12	4	10.0	3.3	35.0	313.0
12	5	10.2	3.2	35.0	313.0
12	6	10.3	3.2	35.0	312.0
12	7	10.4	3.1	35.0	312.0
12	8	10.6	3.0	34.9	311.0
12	9	10.6	3.0	34.9	311.0
12	10	10.5	3.0	34.9	310.0
13	0	10.0	3.3	35.0	312.0
13	1	9.7	3.3	35.0	312.0
13	2	9.8	3.2	35.0	312.0
13	3	10.0	3.2	35.0	312.0
13	4	10.2	3.2	35.0	312.0
13	5	10.4	3.2	35.0	312.0
13	6	10.4	3.1	35.0	312.0
13	7	10.6	3.1	35.0	312.0
13	8	10.6	3.1	35.0	312.0
13	9	10.7	3.1	35.0	312.0
13	10	10.5	3.0	35.0	312.0

R.3, Cont.

14	0	10.2	3.5	34.8	312.0
14	1	10.0	3.2	34.8	312.0
14	2	10.0	3.2	34.8	312.0
14	3	10.2	3.2	34.8	312.0
14	4	10.4	3.2	34.7	312.0
14	5	10.6	3.1	34.7	311.0
14	6	10.6	3.1	34.7	311.0
14	7	10.7	3.1	34.7	311.0
14	8	10.8	3.0	34.5	310.0
14	9	11.2	2.9	35.0	310.0
14	10	10.4	2.9	35.0	310.0
15	0	10.2	3.5	34.8	312.0
15	1	10.0	3.5	34.8	312.0
15	2	10.2	3.4	34.8	312.0
15	3	10.2	3.3	34.8	312.0
15	4	10.4	3.3	34.8	312.0
15	5	10.8	3.2	34.7	312.0
15	6	11.0	3.0	34.4	310.0
15	7	11.0	3.0	34.4	310.0
15	8	10.8	3.0	34.4	310.0
15	9	11.0	3.0	34.3	310.0
15	10	11.1	3.0	34.3	310.0
16	0	10.6	3.3	34.7	311.0
16	1	10.5	3.3	34.7	311.0
16	2	10.7	3.3	34.7	311.0
16	3	10.9	3.3	34.7	311.0
16	4	11.0	3.3	34.7	311.0
16	5	11.0	3.2	34.7	312.0
16	6	11.2	3.2	34.7	312.0
16	7	11.4	3.2	34.7	311.0
16	8	11.0	3.1	34.5	310.0
16	9	10.8	3.0	34.4	310.0
16	10	11.0	3.0	34.4	310.0
17	0	10.4	3.3	34.0	312.0
17	1	10.6	3.5	34.1	312.0
17	2	10.9	3.4	34.1	312.0
17	3	11.2	3.4	34.0	312.0
17	4	11.4	3.4	34.1	312.0
17	5	11.4	3.4	34.1	312.0
17	6	11.4	3.4	34.1	312.0
17	7	11.8	3.2	34.0	311.0
17	8	11.6	3.1	34.0	311.0
17	9	10.0	3.0	34.0	311.0
17	10	11.4	3.0	34.0	311.0

R.3, Cont.

18	0	10.6	3.9	35.0	314.0
18	1	11.0	3.7	34.7	312.0
18	2	11.4	3.7	34.7	312.0
18	3	11.8	3.7	34.7	312.0
18	4	11.8	3.7	34.5	312.0
18	5	12.0	3.5	34.5	312.0
18	6	12.2	3.2	34.9	312.0
18	7	12.2	3.2	34.8	311.0
18	8	12.1	3.0	34.8	311.0
18	9	12.2	3.0	34.0	309.0
18	10	12.1	2.5	34.9	308.0

R.4 SEASONAL REFERENCE DATA FOR SUMNER, 1985.

STATION	DEPTH (m)	DISSOLVED OXYGEN (mg/L)	TEMPERATURE (°C)	SALINITY (o/oo)	CONDUCTIVITY (100 x μ S /cm)
1	0	10.0	8.0	29.5	320.0
1	1	9.5	9.5	29.0	325.0
1	2	9.5	10.0	29.0	325.0
1	3	10.4	9.0	28.5	315.0
1	4	10.6	7.5	30.0	310.0
1	5	10.8	5.5	30.0	295.0
1	6	11.0	4.8	30.0	290.0
1	7	11.1	4.0	30.0	285.0
1	8	11.1	4.0	30.0	285.0
1	9	10.9	3.8	30.0	280.0
1	10	11.0	3.5	31.0	280.0
2	0	9.8	9.0	29.0	320.0
2	1	10.0	8.8	29.5	315.0
2	2	10.2	8.8	29.5	320.0
2	3	10.6	7.0	29.5	310.0
2	4	10.8	6.0	30.0	305.0
2	5	11.0	5.8	30.0	300.0
2	6	11.1	5.0	30.0	295.0
2	7	11.2	5.0	30.0	295.0
2	8	11.2	4.8	30.0	295.0
2	9	11.2	4.8	30.0	290.0
2	10	11.2	4.5	30.0	295.0
3	0	9.8	10.0	29.5	320.0
3	1	10.4	10.0	28.5	320.0
3	2	10.6	9.0	29.0	320.0
3	3	10.8	8.5	29.5	315.0
3	4	11.0	8.5	29.5	315.0
3	5	11.2	8.5	29.5	315.0
3	6	11.5	7.0	29.0	310.0
3	7	11.6	6.0	30.5	300.0
3	8	12.0	5.0	29.5	290.0
3	9	11.8	4.0	29.5	285.0
3	10	12.2	3.2	31.0	285.0

R.4, Cont.

4	0	10.0	9.0	28.5	320.0
4	1	10.0	9.0	28.5	320.0
4	2	10.9	8.5	29.0	315.0
4	3	11.2	8.5	29.5	320.0
4	4	12.4	7.8	29.0	310.0
4	5	12.8	7.0	29.5	305.0
4	6	13.0	5.5	29.5	300.0
4	7	13.2	4.8	30.0	295.0
4	8	13.5	4.0	30.0	290.0
4	9	13.6	4.0	30.0	290.0
4	10	13.6	4.0	30.0	285.0
5	0	10.0	10.0	29.5	325.0
5	1	10.0	10.0	29.0	325.0
5	2	10.4	9.5	29.5	325.0
5	3	12.0	8.0	29.0	315.0
5	4	12.1	7.5	30.0	310.0
5	5	12.4	7.0	30.0	310.0
5	6	12.4	6.0	29.5	300.0
5	7	12.5	5.2	30.0	295.0
5	8	12.6	5.0	30.0	295.0
5	9	12.8	4.0	30.0	290.0
5	10	12.9	3.5	30.5	285.0
6	0	10.0	10.5	29.0	330.0
6	1	10.0	10.5	29.0	330.0
6	2	10.0	9.0	29.0	320.0
6	3	10.2	8.0	29.5	315.0
6	4	10.6	6.0	29.5	300.0
6	5	10.8	4.2	30.5	290.0
6	6	11.0	4.0	30.0	290.0
6	7	11.0	4.0	30.0	290.0
6	8	11.2	3.5	30.5	290.0
6	9	11.2	3.1	31.0	285.0
6	10	11.2	3.0	31.0	285.0
7	0	10.0	10.0	31.0	330.0
7	1	10.0	10.0	29.5	330.0
7	2	10.0	8.0	30.5	315.0
7	3	10.1	7.0	29.5	310.0
7	4	10.0	6.5	29.5	305.0
7	5	10.0	6.5	30.0	305.0
7	6	10.0	6.2	30.5	305.0
7	7	10.0	6.0	30.0	305.0
7	8	10.1	5.2	30.0	300.0
7	9	10.3	4.0	29.5	290.0
7	10	10.3	3.4	30.0	285.0

R.4, Cont.

8	0	10.0	10.5	29.5	330.0
8	1	10.2	10.5	29.0	330.0
8	2	10.2	10.0	29.5	330.0
8	3	10.2	9.0	29.5	320.0
8	4	10.3	8.0	29.5	310.0
8	5	10.2	8.0	30.0	315.0
8	6	10.2	7.5	30.0	310.0
8	7	10.0	7.0	29.5	310.0
8	8	10.0	5.0	30.0	295.0
8	9	10.0	4.0	30.0	290.0
8	10	10.0	4.0	30.0	285.0
9	0	10.2	9.5	29.5	320.0
9	1	10.4	9.0	29.5	320.0
9	2	10.4	9.0	29.5	325.0
9	3	10.3	9.0	29.5	325.0
9	4	10.2	9.0	29.5	320.0
9	5	10.2	7.5	29.5	315.0
9	6	10.5	6.0	29.5	300.0
9	7	10.8	5.0	30.0	295.0
9	8	10.9	4.5	30.5	290.0
9	9	11.0	4.0	30.5	290.0
9	10	11.0	4.0	30.5	290.0
10	0	10.2	10.0	29.5	330.0
10	1	10.4	10.0	29.5	330.0
10	2	10.3	9.5	28.5	330.0
10	3	10.3	7.0	30.0	310.0
10	4	10.3	6.8	30.0	310.0
10	5	10.2	6.0	30.0	305.0
10	6	10.2	5.5	30.0	300.0
10	7	10.2	5.0	30.0	300.0
10	8	10.2	5.0	30.0	300.0
10	9	10.5	4.5	30.5	295.0
10	10	10.6	4.0	30.5	295.0
11	0	10.4	10.0	29.5	330.0
11	1	10.4	10.0	29.5	330.0
11	2	10.2	10.0	29.0	320.0
11	3	10.4	8.0	29.5	310.0
11	4	10.5	6.5	29.5	305.0
11	5	10.5	6.0	30.0	300.0
11	6	10.4	6.0	29.5	300.0
11	7	10.6	5.5	30.5	290.0
11	8	10.4	5.0	30.5	290.0
11	9	10.6	4.8	30.0	290.0
11	10	10.2	4.0	30.0	290.0

R.4, Cont.

12	0	10.4	9.5	29.5	330.0
12	1	10.4	9.5	29.5	330.0
12	2	10.4	9.5	30.0	330.0
12	3	10.4	9.0	29.5	325.0
12	4	10.7	6.5	29.5	310.0
12	5	10.5	6.0	29.5	295.0
12	6	10.2	4.0	30.5	295.0
12	7	10.2	4.0	30.0	290.0
12	8	10.5	4.0	30.0	290.0
12	9	10.7	3.5	30.5	285.0
12	10	10.7	3.3	30.5	290.0
13	0	10.2	9.5	29.0	330.0
13	1	10.7	9.0	30.0	330.0
13	2	10.2	9.0	27.5	305.0
13	3	10.2	6.0	30.5	305.0
13	4	10.2	5.5	30.0	300.0
13	5	10.0	5.5	30.0	300.0
13	6	10.0	5.0	31.0	300.0
13	7	10.0	5.0	31.0	300.0
13	8	10.0	4.8	31.0	295.0
13	9	10.4	4.0	30.5	290.0
13	10	10.4	4.0	30.5	290.0
14	0	10.4	9.5	29.5	330.0
14	1	10.0	9.0	30.0	325.0
14	2	10.6	9.0	30.0	330.0
14	3	10.6	9.0	30.0	320.0
14	4	10.9	6.0	30.0	300.0
14	5	10.2	6.0	30.0	300.0
14	6	10.2	5.5	30.0	300.0
14	7	10.0	5.0	30.0	300.0
14	8	10.0	4.6	30.5	295.0
14	9	10.6	4.5	30.5	295.0
14	10	10.8	4.3	30.5	295.0

R. 4, Cont.

15	0	10.1	9.5	29.0	325.0
15	1	10.4	9.0	29.5	320.0
15	2	10.6	9.0	30.5	330.0
15	3	10.6	9.0	30.0	330.0
15	4	10.6	9.0	28.0	320.0
15	5	10.6	5.5	30.0	300.0
15	6	10.6	5.0	30.0	300.0
15	7	10.7	4.5	31.0	295.0
15	8	10.8	4.0	30.5	290.0
15	9	10.8	4.0	30.5	290.0
15	10	10.8	4.0	30.5	290.0
16	0	10.4	9.0	30.0	325.0
16	1	10.6	9.0	30.0	325.0
16	2	10.6	9.0	29.5	325.0
16	3	10.6	9.0	29.5	325.0
16	4	10.6	9.0	29.5	325.0
16	5	10.6	8.5	29.5	325.0
16	6	10.7	6.0	29.5	300.0
16	7	10.7	4.5	30.5	295.0
16	8	10.7	4.5	30.5	295.0
16	9	10.8	4.5	30.5	295.0
16	10	10.9	4.2	31.5	295.0
17	0	10.0	9.5	29.5	325.0
17	1	10.2	9.2	30.0	325.0
17	2	10.3	9.0	30.0	325.0
17	3	10.4	9.0	29.5	325.0
17	4	10.4	7.5	30.0	315.0
17	5	10.2	7.0	29.5	310.0
17	6	10.2	6.0	29.0	300.0
17	7	10.1	5.5	30.0	300.0
17	8	10.0	5.5	29.5	295.0
17	9	10.1	5.0	30.0	295.0
17	10	10.4	4.0	30.0	295.0

R.5 Reference Laboratory Data for Fall

LOCATION	BOD (mg/L)	COD (mg/L)	S.S. (mg/L)	pH
1	3.2		36.0	7.75
1A	3.2		46.0	7.73
2	3.4		41.0	7.78
2A	3.3		19.0	7.81
3	3.2		31.0	7.60
3A	3.2		39.5	7.84
4	2.7		40.0	7.83
4A	2.5		38.0	7.83
5	2.8		26.0	7.84
5A	2.8		38.0	7.84
6	2.6		40.0	7.83
6A	2.7		39.0	7.84
7	2.7		42.0	7.84
7A	2.9		38.0	7.85
8	2.9		38.0	7.86
8A	2.7		38.0	7.89
9	2.7		37.0	7.86
9A	2.6		34.0	7.87
10	2.6		32.0	7.86
10A	3.0		35.0	7.84
11	3.0		44.0	7.86
11A	3.0		32.0	7.86
12	3.0		37.0	7.86
12A	3.0		35.5	7.86
13	2.4		37.0	7.75
13A	3.0		37.0	7.90
14	2.7		37.0	7.90
14A	2.8		36.5	7.91
15	2.9		35.0	7.91
15A	2.8		35.0	7.90
16	3.0		33.0	7.89
16A	2.6		35.0	7.90
17	2.6		35.0	7.90
17A	2.5		37.0	7.91
18	2.8		34.0	7.91
18A	2.9		38.0	7.91

R.6 Reference Laboratory Data for Winter

LOCATION	BOD (mg/L)	COD (mg/L)	S.S. (mg/L)	pH
1	4.0		30.8	7.52
1A	2.0		37.6	7.95
2	3.0		31.2	7.74
2A	2.0		35.4	7.95
3	2.0		31.2	7.91
3A	2.0		33.2	7.94
4	3.0		31.4	7.87
4A	2.0		34.4	7.95
5	3.0		33.0	7.84
5A	1.0		37.8	7.96
6	2.0		37.8	7.92
6A	1.0		38.2	7.96
7	3.0		39.4	8.02
7A	1.0		36.4	8.02
8	2.0		34.8	8.00
8A	2.0		34.8	8.05
9	2.0		34.8	8.03
9A	1.0		34.0	8.04
10	1.0		31.4	8.02
10A	1.0		33.0	8.01
11	1.0		34.2	7.99
11A	1.0		37.0	8.03
12	2.0		39.4	7.99
12A	1.0		38.6	8.04
13	2.0		33.4	7.99
13A	1.0		36.6	8.00
14	2.0		34.8	8.00
14A	1.0		34.8	8.10
15	2.0		38.4	8.05
15A	1.0		38.2	8.08
16	1.0		39.0	8.00
16A	1.0		37.6	8.05
17	2.0		34.8	8.03
17A	1.0		37.6	8.01
18	2.0		36.8	8.00
18A	1.0		36.2	8.01

R.7 Reference Laboratory Data for Spring

- 452 -

LOCATION	BOD (mg/L)	COD (mg/L)	S.S. (mg/L)	pH
1	2.1	441.6	29.2	8.24
1A	1.9	46.1	28.2	8.09
2	1.6	157.4	24.2	8.21
2A	1.1	107.5	27.4	8.06
3	2.0	107.5	28.2	8.19
3A	1.4	81.2	24.0	8.02
4	2.0	322.6	27.0	8.17
4A	2.2	130.6	23.8	8.13
5	2.0	161.3	24.8	7.87
5A	1.5	92.1	30.4	7.82
6	2.2	257.3	22.0	8.21
6A	1.8	134.4	24.8	8.08
7	1.8	88.3	29.6	8.18
7A	1.9	295.7	19.6	8.19
8	2.1	184.3	22.4	8.18
8A	2.0	234.5	29.2	8.18
9	1.9	226.6	22.4	8.20
9A	1.8	57.6	22.6	8.21
10	1.9	195.8	25.2	8.15
10A	1.7	126.6	20.6	8.15
11	1.4	215.0	31.0	8.28
11A	1.4	169.0	29.8	8.26
12	1.5	253.4	23.6	8.28
12A	1.3	303.4	30.2	8.24
13	1.2	345.6	28.4	8.30
13A	1.3	264.9	24.2	8.29
14	1.4	368.7	32.0	8.32
14A	1.4	288.0	31.2	8.27
15	1.0	161.4	27.6	8.32
15A	1.4	207.4	35.8	8.30
16	1.4	230.4	25.2	8.31
16A	1.3	218.9	30.0	8.30
17	1.4	284.2	31.4	8.34
17A	1.1	203.5	26.0	8.30
18	1.4	57.6	25.6	8.27
18A	1.4	261.1	31.4	8.26

R.8 Reference Laboratory Data for Summer

LOCATION	BOD (mg/L)	COD (mg/L)	S.S. (mg/L)	pH
1	3.3	24.0	5.6	8.07
1A	2.8	22.0	6.6	7.97
2	3.5	18.0	20.0	8.02
2A	3.2	22.2	6.4	7.96
3	3.7	22.4	5.8	8.01
3A	2.9	18.8	5.0	7.93
4	3.7	22.6	7.0	8.02
4A	2.6	23.4	7.6	7.91
5	3.7	21.9	5.4	8.03
5A	2.9	18.4	5.2	7.96
6	3.8	21.4	12.2	8.08
6A	2.6	18.2	6.6	7.95
7	3.5	22.8	2.6	8.07
7A	2.9	20.2	2.2	7.95
8	3.5	22.3	7.2	8.10
8A	2.4	21.5	3.0	8.09
9	4.0	19.4	6.6	8.09
9A	2.6	22.6	8.6	8.00
10	3.2	21.8	5.2	8.12
10A	3.0	19.8	5.2	8.04
11	3.5	21.8	3.0	8.11
11A	2.9	21.2	22.0	8.06
12	3.0	18.0	9.6	8.13
12A	3.1	22.4	8.8	8.04
13	3.0	24.2	8.6	8.11
13A	2.6	20.9	6.4	8.02
14	2.8	24.1	10.6	8.12
14A	2.7	13.5	5.8	8.04
15	2.6	21.0	7.8	8.11
15A	2.5	23.8	10.2	8.03
16	2.7	24.0	7.0	8.10
16A	2.5	23.3	7.0	8.02
17	3.1	22.7	12.0	8.09
17A	2.3	23.8	11.0	8.04

Table R.9: Field data for the Reference site outside the Harbour,
September 1984-August 1985, inclusive.

Season	Depth (m)	Temperature (°C)	Salinity (o/oo)
Fall	0	8.5	32.2
	20	8.3	32.3
	100	5.0	33.6
	150	7.0	34.2
	200	7.4	34.4
Winter	0	6.7	32.7
	5	5.2	32.7
	20	6.0	32.6
	25	7.4	32.6
	50	7.5	32.7
	75	12.2	32.9
	95	16.0	33.4
	115	16.6	32.5
	180	15.5	33.8
	190	16.3	34.2
	200	16.1	34.5
Winter	0	0.8	32.7
	55	0.6	32.8
	71	2.2	32.9
	119	4.1	33.6
	131	9.0	33.7
	200	9.4	34.5
Spring	0	7.7	32.3
	50	5.0	32.5
	100	6.5	33.7
	200	7.5	34.4
Summer	0	17.5	32.8
	30	9.5	32.8
	75	4.8	33.6
	125	7.3	34.3

Table R.10: Laboratory data for the Reference site outside the Harbour,
September 1984-August 1985, inclusive.

Season	BOD (mg/L)	S.S. (mg/L)	pH
Fall	3.3 3.2	35.0 45.0	7.95 7.96
Winter	5.0 3.1	27.9 28.1	
Spring	1.7 1.7	31.0 33.0	8.10 8.02
Summer	4.2 3.3	45.0 58.0	8.03 8.10

BIBLIOGRAPHY

BIBLIOGRAPHY

- Baca, E. Bediment, P.B. and Oslon, R. Urban Impacts of Water Supply Reservoir, J. ASCE. 1982. (108). EE1 73-87.
- Barnes, R.S.K. Ph.D and Green, J. Prof.D.Sc. 1972. The estuarine environment, Applied Science Publishers Ltd., London.
- Bedford Institute of Oceanography. Journal of Geophysical Research, January 20th, 1980. Volume 85, No. C1.
- Brady, Alan. Memorandum on the operation of the wastewater treatment plants. 1984. M.A.P.C. REPORT.
- Cabelli, V.J. Evaluation of recreational water quality, the EPA approach. In proc. International Symposium on Biological Indicators of Water Quality. Univ. of Newcastle. Upon Tyne, September. 1979.
- Canadian-British Engineering. Pollution control city of Dartmouth. Halifax, N.S. 1969.
- Canale, Raymond. Modelling of biochemical processes in aquatic ecosystems. 1976.
- Canplan Oceanology Limited. Evaluation of data on Halifax Harbour and its use in a predictive model to determine the effect of effluent on receiving water quality. Ocean Engineering Consultants. Halifax, N.S.
- Canplan Consultant Limited. Design brief of the Bedford Highway interceptor sewers. Halifax, N.S. September, 1975.
- CBCL Limited. Report Number 80655. 1981.
- Carter, H.H., Carpenter, J.H., and Whaley, R.C.. The Bactericidal Effect of Seawater Under Natural Conditions. J. Wet. Pollut. Control Fed., 1967, Volume 39, (1184-1189).
- Cederwell, K., Gorunssen, G.G., and Svensson T., Subsequent Dispersion Methods of Measurement. Discharge of sewage from sea outfalls. International Symposium Proceedings. 1974.
- Clarke, N.A., Berg, G., Kabler, P.W., and Chung, S.L., Human Enteric Viruses in Water: Source Survival and Removability. Proc. 1st Int. Conf. Wat. Pollut. Res. London, 1962, Vol 2, (523).

- Correl, D.L., Pierce, J.W., Faust, M.A.. A quantitative study of the nutrient, sediment, and coliform bacterial constituents of water runoff from the Rhode River watershed, Smithsonian Institution, Radiation biology laboratory, National museum of natural history of Smithsonian Institute, Chesapeake Bay center for Environmental Studies. Edgewater, Maryland.
- Department of Development. Halifax metro factbook. Nova Scotia. Fourth Edition. November, 1981.
- Department of the Environment. Pollution control advisory committee report. Ottawa, Ontario. January, 1977.
- Department of the National Defense. Shannon Park P.M.Q. pollution control study. Dartmouth, N.S. January, 1971.
- Derosa, S., Damiani, V. and Ambersano, E. Indagine sullo stato di contaminazione dei sedimenti superficiali del tratto del golfo di nupoli, tra visola di nisdue torre del greco. Atti del convergno scientifizo nazionale. Progetto Finalizzato oceanografia efondi martini, November 1981.
- Donstan, W.M. A Comparison of the P-I Relation in Phylogenatically Different Microalgae. J. Exp. Mar. Biol. Ecol. 1973. Volume 13 (181-187).
- Drinkwater, K. and Taylor, G. Monthly means of the temperature, salinity and density along the Halifax section. B.I.O. marine ecology lab., Series 1093. April 1982.
- Dursi, Louis M. Report of the Bedford Basin pollution committee. Halifax, N.S. 1984.
- Eighny, T.T., D. Maratea, P. Bishop. March, 1983. Electron microscopic examination of wastewater biofilm formation and structural components. Department of Civil Engineering and Microbiology. University of New Hampshire, Durham.
- Ferguson. John F. Chemical aspects of the lime sea water process. April, 1984.
- Fisheries Research Board of Canada. The spatial and seasonal distribution of coliforms in Bedford Basin. Technical Report No. 352, Halifax, N.S. 1972.
- Freeman, K. The spatial and seasonal distribution of coliforms in bedford basin. Technical Reportr #352. Fisheries Research Board of Canada. 1972.

- Fujioka, R.S., Hashimoto, H.H., Sinak, E.B. and Young, R.H.F. Applied and Environmental Microbiology. 1981. Volume 41 (690).
- Gameson, A.L.H. Discharge of sewage from sea outfalls. International Symposium, 1974
- Garbow, W.O.K. The Virology of Wastewater Treatment. Water Resources. 1968. Volume 2. (675).
- Gardner, G.B., Nowell, R.M. and Smith, J.D. Turbulent Processes in Estuaries. Edited by Hamilton, P. and MacDonald, K. Estuarine and Wetland Processes, Plenum Press, N.Y. and London. Vol. 11 of Marine Science Series. 1979.
- Gerba, C.P. and MacLeod, J.S., Effects of Sediments on the Survival of Escherichia Coli in Marine Waters. Applied Environmental Microbiology. 1976. Volume 32 (114-120).
- Greenberg, A.E. Survival of Enteric organisms in Seawater. (A literature review) Public Health Reports January, 1956. Vol. II, No. I.
- Hamilton, Peter, Keith MacDonald. Estuarine and wetland processes with emphasis on modelling. Plenum Press, New York, London. 1979.
- Hachey, H.B. The weatherman and coastal fisheries. Transactions of the American Fisheries Society. Volume 64. 1934.
- Hachey, H.B. North Atlantic cyclones and coastal waters. Fisheries Experimental Station (Atlantic). Note #37.
- Hachey, H.B. A Winter Intrusion of Scope Water on the Scotian Shelf. Journal of Fisheries Resources Board of Canada. 1953. Vol. 10. No. 3. (148-53).
- IBID Jellyfish Forecast the Hurricane of September 21st. Atlantic Biological Station, Note #64, (13-15). Communications No. 5.
- IBID. Water Replacement and Their Significance to Fishery. Papers in Marine Biology and Oceanography Supplement to Volume 3 of Deep Sea Research. (68-73).
- IBID The Water Man and Coastal Fisheries. Transactions of the American Fisheries Society. Volume 64. 1934.
- Harris, G.P. Vertical mixing mechanisms and their effects on primary production of phytoplankton. 1973. Scientific series No. 33. Inland Waters Directorate, Canada Center for Inland Waters. Burlington, Ontario.
- Hatcher, Patrick G., and Phillip A. Macgillvary. Sewage contamination in the New York Bight. Ocean Chem Limited, Dartmouth, N.S.

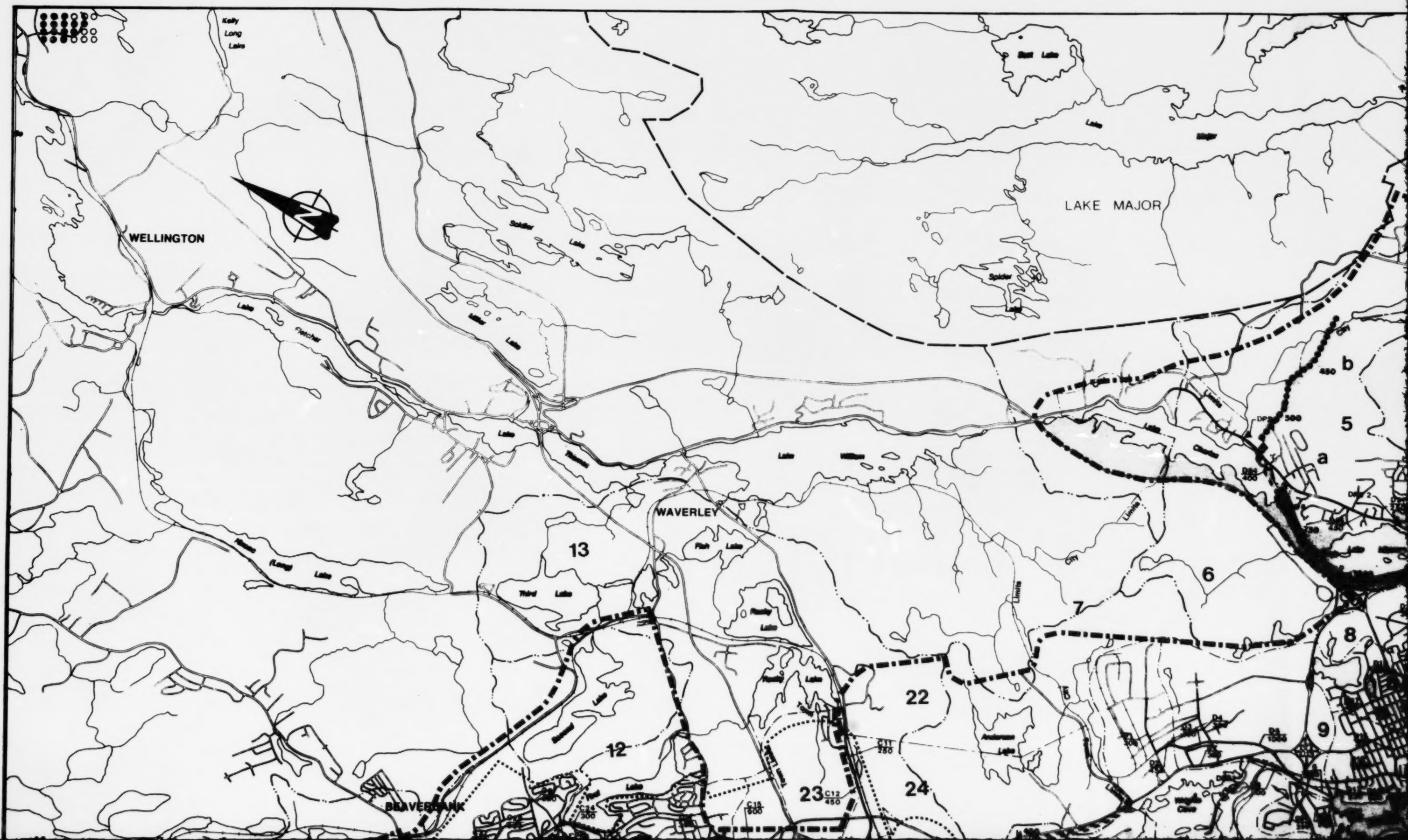
- Heath, R. A. Flushing of Coastal Embayments by Changes in Atmospheric Conditions Limnology and Oceanography. Nov., 1973. Volume 18 (6).
- Humphrey, B. Kgelberg, S. and Marshall, K.C. Responses of Marine Bacteria Under Starvation Conditions at a Solid-Water Interface. Applied and Environmental Microbiology. Volume 45, No. 1 (43-47).
- Hydrotechnic Corp. New concepts for the treatment of sewage discharged to the sea. Consulting Engineers, New York, New York. 1978.
- Institute of the Environmental Studies. Oceanography of Halifax Inlet in relation to problems of sewage disposal. Halifax, N.S. 1984.
- Irwin, B., T. Platt, A.D. Jassby and P.V. Subba Rao. The relation between light intensity and photosynthesis by phytoplankton. Results of the experiments at three stations in the coastal waters of Nova Scotia. Department of the Environment, Fisheries and Marine Services. Technical Report #595. 1975.
- Izzo, G. et al. Faecal Contamination of Marine Sediments in a Stretch of the Gulph of Nepals. Water, Air and Soil.
- Kelly, S. M. and Sanderson, W. W. Density of Enteroviruses in Sewage. J. Wat. Pollut. Control Fed. 1960, Volume 32 (1269).
- Kenner, B. A., Clark, H. F. and Kabler P.W. Cultivation and Enumeration of Streptococci in Surface Waters. Appl. Microbiol, 1961 Volume 9 (15).
- Kirk, P.W.W., J.N. Lester, R. Perry. Amenability of Nitrolotriacetic Acid to Biodegradation in a Marine Simulation. (Public Health Engineering Laboratory. Department of Civil Engineering, Imperial College, London, (U.K.) Marine Pollution Bulletin. Volume 14, No. 3 (88-93).
- Kraul, D.P. Bedford basin data report. Technical Report #120. Marine Ecology institute, Dartmouth, Nova Scotia. 1967.
- Langford, C.J., A.R. Coote. Proposed survey of Halifax Harbour. Unpublished Manuscript for International Circulation. 1963.
- Lauff, George H. Estuarines. Washington, D.C. American Association for the Advancement of Science. (Publication No. 83).
- Leim, A. H. and H.B. Hachey. 1935. A Transgression of Marginal Waters Over the Scotian Shelf. American Fisheries Society, Transactions. Volume 65. 1935.

- Lewis, Marlon R. Department of Oceanography, Dalhousie University, Halifax, Nova Scotia. Biological oceanographic aspects of sewage addition to Halifax inlet.
- Lewis, M. R. and Platt, T. Scales of Variability in Estuarine Ecosystem. Estuarine Comparisons Academic Press, Inc. (3-20).
- Lick, W. Paul, J. and Sheng, Y.P. The Dispersion of Contaminants in the Near-Shore Region. Modeling Biochemical Processes in Aquatic Systems.
- Livingstone, D.J. The Effect of Submarine Wastewater Discharge on the Bacterial quality of Surf Water. Water Science Technology. 1982. Volume 14 (1-11).
- IBID An Appraisal of sewage pollution along a section of the Natal coast. J. Hyg., Camb., 67 (209-223).
- Longard, J.R. and R.E. Banks.. Wind-induced Vertical Movement of the Water on an Open coast. American Geophysical Union. June, 1952 Volume 33, No. 3, (377-80).
- Loucks, R.H. Oceanology Limited, and Integrated Survey Systems Limited, A Division of Whitman, Benn and Associates Limited. Applied Marine Research Limited. A consideration of the ecological effects of sewage discharge into Halifax inlet prepared for the Metropolitan Area Planning Commission by Applied Marine Research Limited.
- Loucks, R., Lawrence, D. Ingraham, B. Flemming. A Techmigue for Estimating Extreme Ocean Current Vectors. Atlantic Oceans Graphic Laboratory, Marine Sciences Directorate. Dept. of the Environment. Report Series BI-R-73-5.
- Levy, E.M., C.C. Cunningham, C.D.W. Conrad, and J.D. Muffat. The determination of dissolved oxygen in seawater. Bedford Institute of Oceanography, Dartmouth, N.S., August, 1977.
- MacCaull, W.A., T. Platt. Diel Variation in the Photosynthetic Parameters of Coastal Marine Phytoplankton. Limnology and Oceanography. 1977. Volume 22, Number 4, (723-731).
- McGonigal, D., R. Loucks and D. Ingraham. Halifax narrows: sample current meter. Data series/ BI-D-74-5. Sept. 74.
- MacFarlane, D., J. Jones and R. Giffin. Water Supply, Sewerage and Storm Drainage. Task Force Report (Draft). August, 1970. Volume 1.

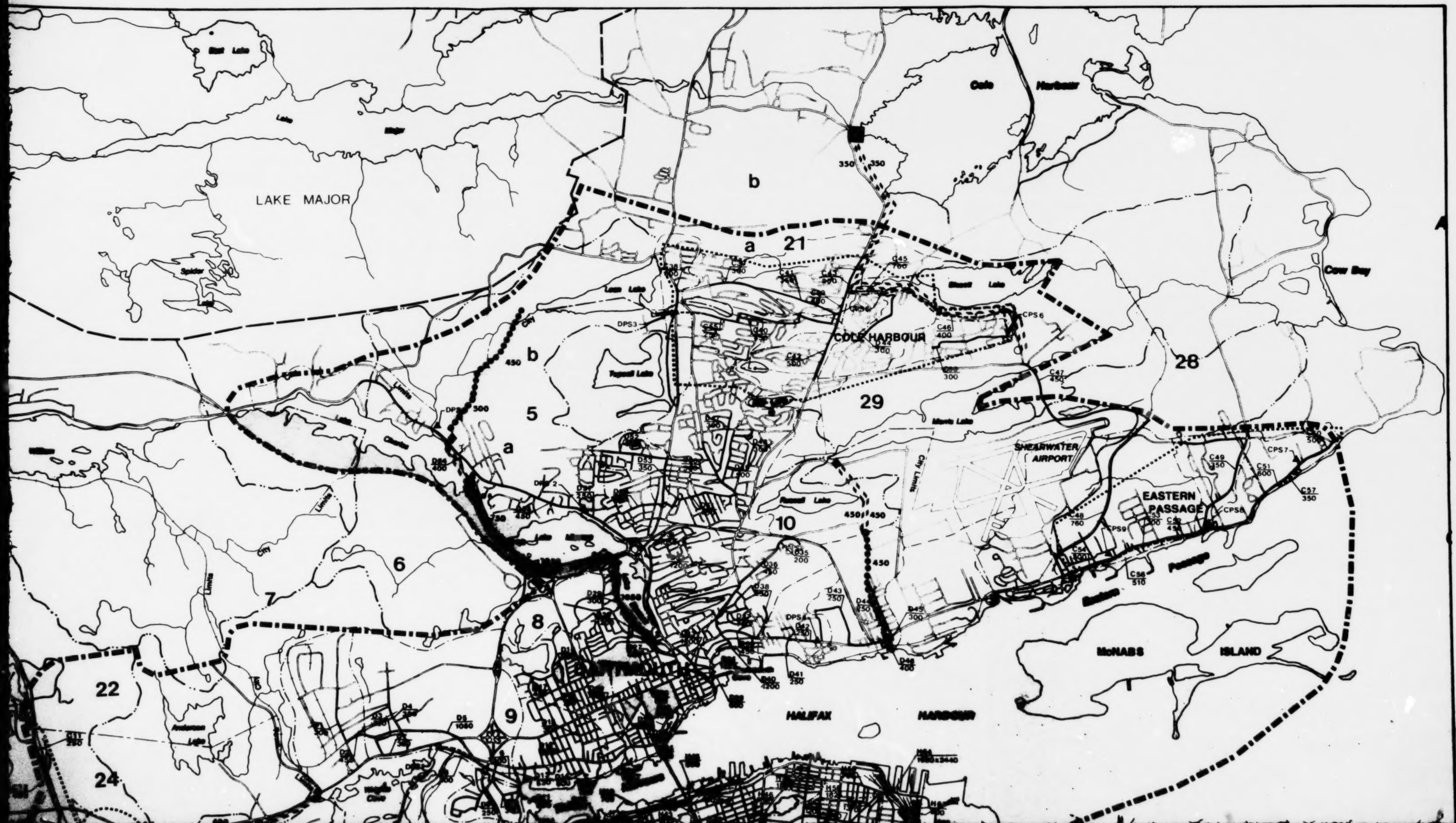
- MacKnight, Dr. Scott. January, 1985. Review of water quality data for Halifax Harbour. Oceanchem Limited, Dartmouth, Nova Scotia.
- MacKnight, S. Halifax Harbour contaminant study.
- MacLaren Atlantic Ltd. Report and Technical Discussion on Sewage and Drainage Works for the City of Halifax.
- MacLaren Consultants. Development of a Halifax water quality management plan. Halifax, N.S. 1982.
- MacLaren Engineers, Planners and Scientists, Inc. Halifax-Dartmouth Regional Plan Review. Sewerage Watersupply and Storm Drainage Study. Report Prepared for MAPC. 1981.
- MacLeod, R.A. On the Role of Inorganic Ions in the Physiology of Marine Bacteria. In "Advances in Microbiology of the Sea". 1968 (95-126).
- Macmillan Bloedel Limited. Effluent dye trace study of the Powell River diffusers. Powell River Division.
- McCormick, Michael J. and Thiruvathuka, John V. Elements of oceanography. Saunders College Publishing. 1976.
- Metropolitan Area Planning Committee. January, 1977. Halifax Harbour investigation. Task Group on Water Supply and Waste Disposal, Halifax, N.S.
- M.A.P.C., J.C. Porter and Associates Limited. 1977. Metropolitan Area of Halifax, Dartmouth and Halifax County regional pollution control study.
- Marr, B.E. Pollution control objectives for municipal type waste discharges in British Columbia. September, 1975 Department of Lands and Forests and Water Resources, Victoria, B.C.
- Myers, E.P. and Harding, E.T. Ocean disposal of municipal wastewater: impact on the coastal environment. Cambridge, Massachusetts. Institute of Technology. 1983.
- Nemerow, Nelson Leonard Ph.D. Stream, lake, estuary and ocean pollution. Van Nostrand Reinhold Company. 1985.
- Neumann, Gerhard and Pierson, William J. Jr. Principles of Physical Oceanography. Englewood Cliffs, N.J. Prentice-Hall, Inc. 1966
- O'Hagan, James R. Report on Bedford Basin Pollution advisory committee of the Council of the Bedford Service Commission. Bedford, N.S.

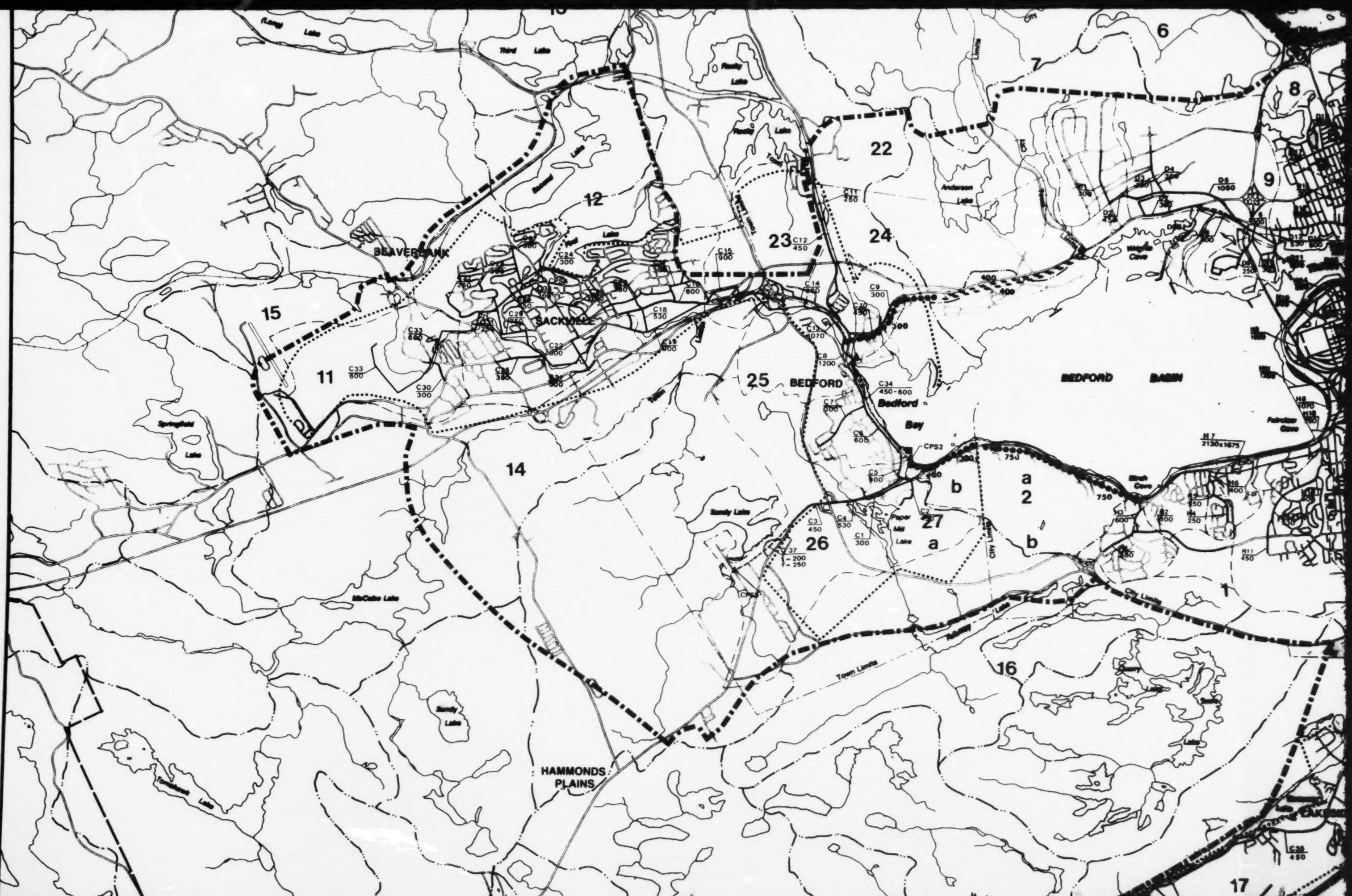
- Paranjape, M.A. and R.J. Conover. Zooplankton of St. Margaret's Bay 1968-1971. Technical Report. #401 Fisheries Research Board of Canada. Marine Ecology Laboratory.
- Petrie, B. and P.C. Smith. January, 1977. Low frequency motions on the Scotian shelf and slope. Atlantic Oceanography, Bedford Institute of Oceanography, Dartmouth, Nova Scotia. Atmosphere Volume 155 No. 3.
- Platt, T., B. Irwin. Primary productivity measurements in St. Margaret's Bay. Fisheries Research Board of Canada, Technical Report #71. Marine Ecology Laboratory, Bedford Institute Of Oceanography. Nova Scotia Department of the Environment Library. FMS-TR-77.
- Platt, T. A. Prakash and Brian Irwin. 1972. Phytoplankton Nutrients and Flushing of Inlets on the Coast of Nova Scotia. Le Naturaliste Canadien. Volume 99, No.4. 1972. (B.I.O.Research.) Physical Oceanography effect of the wind and temperature and pressure on water layer mixing.
- Porter, H.J. and Associates Ltd. Regional Pollution Study. Metropolitan Area of Halifax, Dartmouth and Halifax County. 1977.
- Powell River Division, Macmillan Bloedel Limited. Effluent dye trace study of the Powell River diffuses.
- Project Planning Consultants Ltd. March, 1979. Regional sewage drainage and water supply plan. Volume 1, Summary and Report.
- Riley, Gordon A. Report to the Department of the Environment of the Province of Nova Scotia on the Oceanography of the Halifax Inlet in Relation to Problems of Sewage Disposal. 1974.
- Regional Development Plan Review. Water Supply Sewage and Storm Drainage for Halifax-Dartmouth. Task Force Report. 1980.
- Rosenthal Terminology, Format and Units of Measurement, as Related to Flow Through and Recirculation System in Aquaculture. EIFAC Document. European Inland Fisheries Advisory Commission. United Nations. 1986.
- Ruddick, Dr. Barry. Review of physical oceanography of Halifax Harbour. Department of Oceanography, Dalhousie University, Halifax, Nova Scotia. 1984.
- Sandstrom, H. On the wind-induced sea level changes on the Scotian Shelf. Atlantic Oceanograph Laboratory. 1980.

- Sawyer, Clair N. Perry L. McCarty. Chemistry for environmental engineering (third edition). 1978
- Standard Methods for the Examination of Water and Wastewater, fourteenth edition. 1975.
- Stoker, Stephen H., Seager L. Spencer. 1976 Environmental chemistry: air and water pollution (2nd Edition).
- Strickland, J.D.H. and Parson, T.R. A practical handbook of seawater analysis, bulletin 167 (second edition). Fisheries Research Board of Canada, Ottawa. 1972.
- Sutcliffe Jr., WM., R.H. Loucks and K.F. Drinkwater. Coastal Circulation and Physical Oceanography of the Scotian Shelf and the Gulf of Maine. Journal of Fisheries Research Board of Canada. 1976. Volume 33 #1, (33-115).
- Thomann, R.V. Systems analysis and water quality management. New York. McGraw-Hill. 1972.
- Uni-Bell P.V.C. News. Value engineering for water distribution/sewage collection, Page 4.
- U.S.E.P.A. Kenneth, C. Dr. et al. Handbook. 1984.
- Wetzel, R.G. Limnology. New York, U.S.A. W. B. Publishing Company. 2nd Edition. 1983



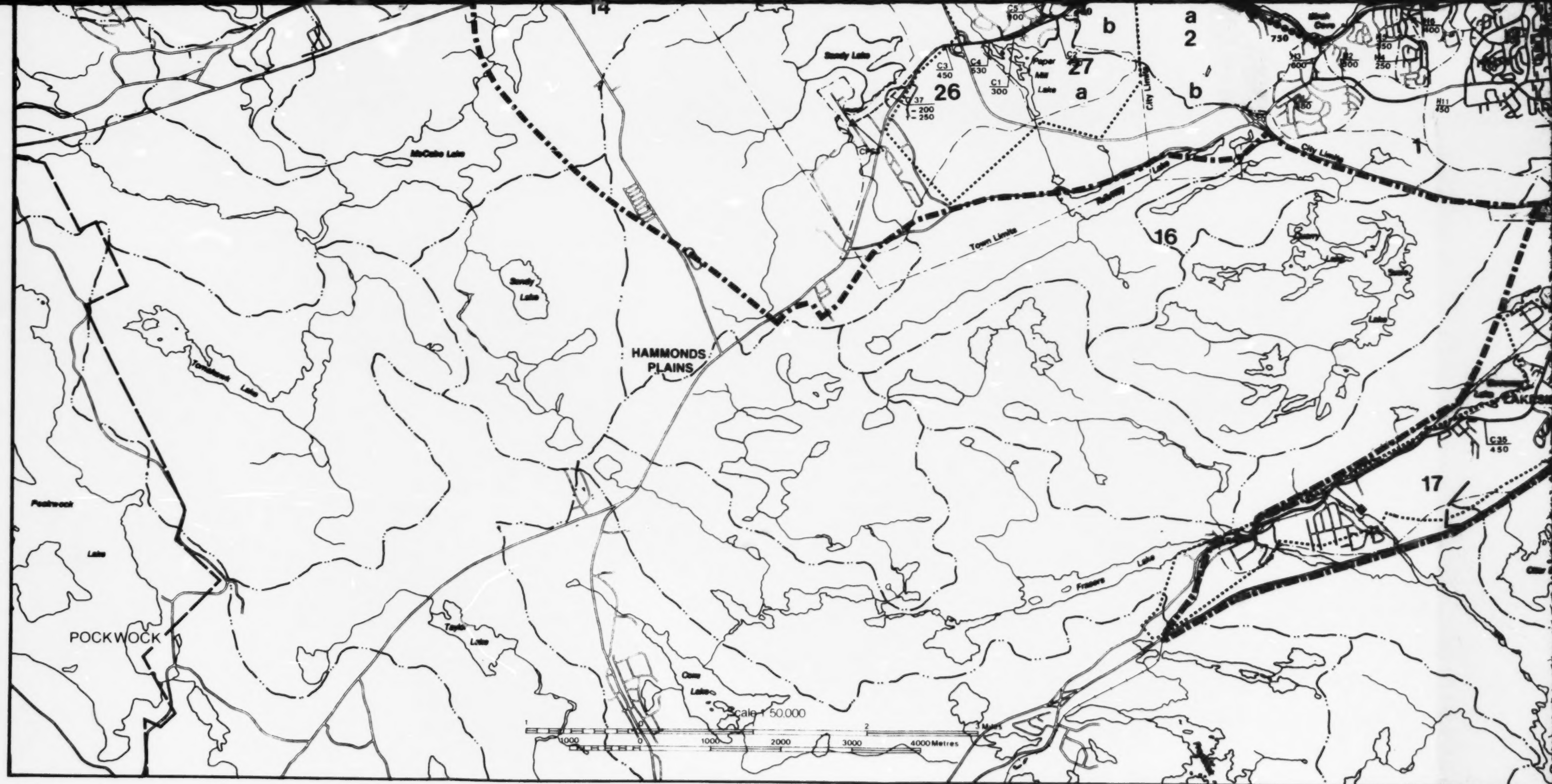












LEGEND:

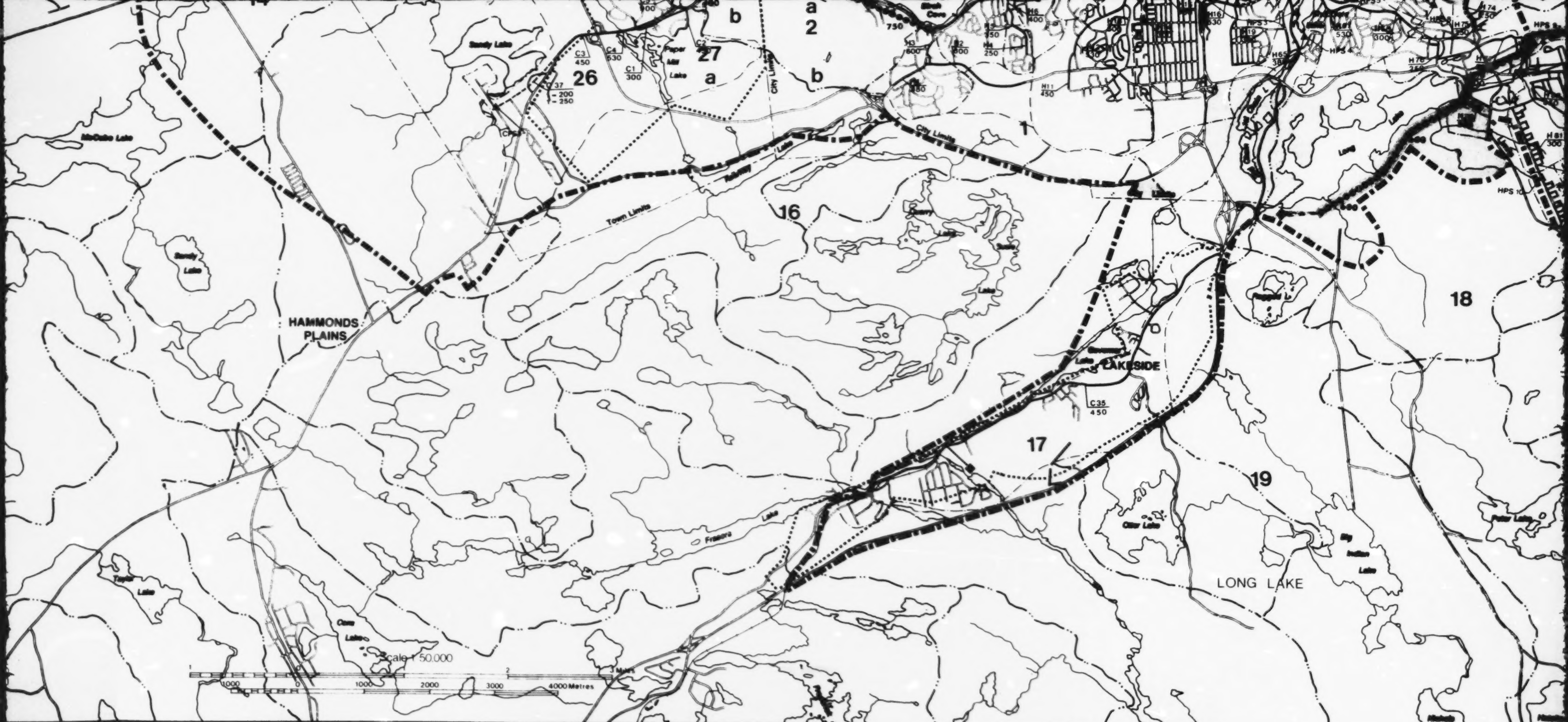
- DEVELOPMENT BOUNDARY
- COUNTY SERVICEABLE AREA BOUNDARY
- WATERSHED BOUNDARY
- PARKLAND CONSERVATION AREA
- ▲ PUMPING STATION
- SEWAGE HOLDING TANKS
- SEWAGE RESERVOIR
- 23 POTENTIAL EXPANSION AREA

- TRUNK SEWER TRIBUTARY AREA
- TRUNK SEWER MAIN
- SEWAGE FORCEMAIN
- OWNER H - CITY OF HALIFAX
D - CITY OF DARTMOUTH
C - COUNTY OF HALIFAX
- REFERENCE NUMBER
- PIPE DIAMETER (mm)
- EXISTING SEWAGE TREATMENT PLANT
- DRAINAGE AREA (Outside of Trunk Sewer Tributary Areas only)

- TRUNK FACILITIES REQUIRED FOR POTENTIAL DEVELOPMENT
- TRUNK SEWER
- SEWAGE FORCEMAIN
- ▲ PUMPING STATION
- SEWAGE TREATMENT PLANT

MacLaren

MacLAREN ENGINEERS PLANNERS & SCIENTISTS INC.



LEGEND:

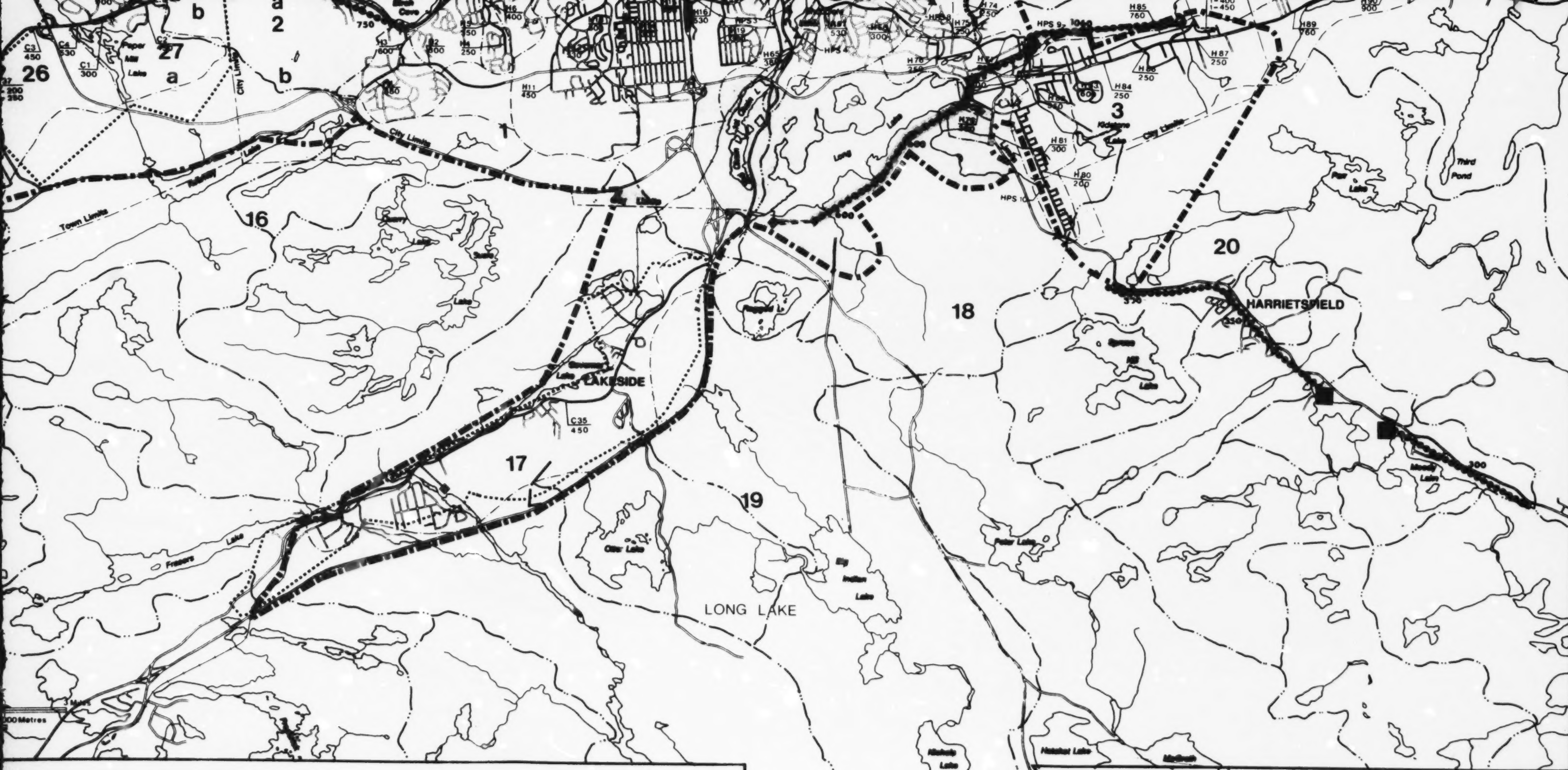
- DEVELOPMENT BOUNDARY
- COUNTY SERVICEABLE AREA BOUNDARY
- WATERSHED BOUNDARY
- PARKLAND CONSERVATION AREA
- ▲ PUMPING STATION
- SEWAGE HOLDING TANKS
- SEWAGE RESERVOIR
- 23** POTENTIAL EXPANSION AREA

- TRUNK SEWER TRIBUTARY AREA
- TRUNK SEWER MAIN
- SEWAGE FORCEMAIN
- OWNER H - CITY OF HALIFAX
D - CITY OF DARTMOUTH
C - COUNTY OF HALIFAX
- 022
300 REFERENCE NUMBER
- PIPE DIAMETER (mm)
- EXISTING SEWAGE TREATMENT PLANT
- DRAINAGE AREA (Outside of Trunk Sewer Tributary Areas only)

TRUNK FACILITIES REQUIRED TO SERVICE POTENTIAL DEVELOPMENT AREAS*

- TRUNK SEWER MAIN
- SEWAGE FORCEMAIN
- ◆ PUMPING STATION
- SEWAGE TREATMENT PLANT

* THE AREAS WERE SELECTED FOR BY THE SEWERAGE, WATER SUPPLY & STORM DRAINAGE TASK FORCE



- TRUNK SEWER TRIBUTARY AREA

—

TRUNK SEWER MAIN

SEWAGE FORCEMAIN

—

OWNER H - CITY OF HALIFAX

—

D - CITY OF DARTMOUTH

C - COUNTY OF HALIFAX

022

300

—

REFERENCE NUMBER

—

PIPE DIAMETER (mm)

■

EXISTING SEWAGE TREATMENT PLANT

DRAINAGE AREA (Outside of Trunk Sewer Tributary Areas only)

TRUNK FACILITIES REQUIRED TO SERVICE
POTENTIAL DEVELOPMENT AREAS*

●●●●●●

TRUNK SEWER MAIN

SEWAGE FORCEMAIN

◆

PUMPING STATION

■

SEWAGE TREATMENT PLANT
- Halifax-Dartmouth Regional Plan Review**
SEWERAGE, WATER SUPPLY, AND STORM DRAINAGE STUDY
- Trunk Sanitary Sewerage**
Existing facilities and those required
to service potential development areas Dwg. No. 2
- * THE AREAS WERE SELECTED FOR COSTING
BY THE SEWERAGE, WATER SUPPLY, AND
STORM DRAINAGE TASK FORCE